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HONDURAS PSELAPHIDAE

PART II

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Drasinus Raffray (1904, p. 148)

This small genus belongs to the tribe Brachyglutini. It is strictly a Neotropical genus containing at present four species. Features of the ventral surface of the head separate *Drasinus* from *Decarthron*. The former has a median carina terminating in a small oval excavation with a narrow opening. The margins of the excavation are separated at the juncture with the submentum. There is a lateral carina on each side of the median carina. In *Decarthron* there are no carinae, either median or lateral, and there is a large median excavation open at the anterior end as described for *Drasinus*. In *Drasinus* the fourth segment of the maxillary palpus (fig. 86) is bluntly rounded at the apex and straight on the ventral side. In *Decarthron* (fig. 85) it is widest near the middle, tapering to a subacute apex. Raffray (1904, p. 148) separated these two genera widely in the tribe on the basis of the ventral surface of the head, but Fletcher (1928, p. 211) and Park (1942, p. 181) related these genera more closely, but neither stated why. Inasmuch as only representatives of *Drasinus hirsutus* Fetcher were available, the comparison below refers only to the material on hand. *Drasinus* and *Decarthron* have in common a 10-segmented antenna, four foveae at the base of each elytron as explained in the discussion under *Decarthron*, an entire sutural elytral stria, and a dorsal stria which extends to a point slightly beyond the middle, these striae originating from the two posterior foveae. The two genera have the same general type of male genitalia, the same modifications of the eighth sternites in the males (see fig. 83), the same flap-like structure behind the antenna (see fig. 81), the same modification of foveae on the mesosternum (see figs. 77 and 78), the same type of tibia as described

for *Decarthron*, both genera are quite hairy, there are two basal carinae on the fourth tergite, and there is the same type of ninth sternite in the males (see fig. 102).

Drasinus hirsutus Fletcher

Drasinus hirsutus Fletcher (1928, p. 211).

The few Honduras specimens examined agree very closely with the description given by Fletcher.

Male.—Length 2 mm.; color brown. Head wider than long; two widely separated vertexal foveae; vertex convex; eyes large and projecting from the head. Maxillary palpus (fig. 86) with the second segment slender on the basal half, club-shaped on the apical half; third triangular; fourth oblique at the base, mesal edge straight, outer edge rounded, widest at the apical two-thirds, apex bluntly rounded, terminated with a short spine. Antenna with the 2nd segment slightly elongate; 3rd elongate, widest at the apex; 4th, 5th, and 6th each elongate; 7th subquadrate; 8th elongate, wider than 7th; 9th slightly elongate, wider than 8th, widest at the apex; 10th ovoidal with a mesal depression on the apical half. Pronotum slightly wider than long, widest at the middle; three basal foveae, lateral ones larger than the the median one; extreme base of pronotum with a row of punctures. The fourth tergite longer than all the others combined; 5th and 6th subequal; seventh longer than sixth; pygidium very slightly emarginate at the apex. Sternites similar in length to the tergites; fourth with two basal carinae very close to the lateral margins, each extending two-thirds the length of the sternite; sixth with a distinct mesal swelling with a fringe of setae on the venter, this structure hidden from a ventral view, but observable from a caudal view. Metasternum convex; a flat median oval area, covered with short setae, adjacent to the middle coxae and extending posteriorly to a point slightly beyond middle of metasternum; a shallow depression posterior to this area. Mesosternum with a small median tubercle at the posterior edge of the median fovea. The ventral surface of the head has a strong median blunt carina terminating anteriorly in a small excavation. This excavation in cleared specimens is oval with a narrow opening ventrally, and the anterior edge of excavation meets the submentum. There are two distinct lateral carinae. Genitalia (fig. 84) with wide ventral plate tapering suddenly near base to an acuta apex; dorsal plate long and narrow, curving abruptly to the right at base; right lobe long and slender.

Female.—Very similar to the male, differing only in the sixth sternite being smoothly convex; eighth sternite simple internally; pygidium not emarginate; anterior tibia having a smaller apical spine. However, these sexual differences are so very slight that it is necessary to clear the specimens in KOH to determine the sex. The modified sixth and eighth sternites and the genitalia are readily seen in cleared males.

Distribution. This species was described from specimens from Mexico and British Honduras. La Ceiba: August 28 (1 ♀). Olanchito: June 21 (1 ♂, 5 ♀), July 5 (1 ♀).

Decarthron Brendel (1865, p. 30)

This is the second largest genus in the tribe Brachyglutini and is chiefly represented in the Neotropics with about sixty species. The most distinctive characters of this genus are the 10-segmented antennae and the large oval excavation on the ventral surface of the head. This excavation is not a true fovea as the rim of it is not entire, the edges not quite joined anteriorly at the juncture with the mentum. The last segment of the maxillary palpus (fig. 85) is widest just before the middle, then tapers to a subacute apex. All of the nine Honduras species studied have at least a median basal fovea on the pronotum. Each elytron has two basal foveae with a dorsal and a sutural stria originating from them; there are two more slightly smaller foveae, one of which is directly anterior to the sutural fovea, and the other is anterior and slightly mesad to the dorsal fovea. Previous workers (Raffray, 1908, p. 249; Park, 1942, p. 185) mention only the two basal foveae from which the striae originate on each elytron, but they do not consider the two foveae anterior to these basal ones. These anterior foveae are readily seen in cleared specimens, but can also be distinguished in uncleared and undissected specimens preserved in alcohol. The sutural stria is complete and the dorsal stria extends just beyond the middle of each elytron. The middle coxa are well separated with the metasternum and the mesosternum meeting truncately. The pubescence is long and rather dense. The fourth tergite is about as long as the rest of the abdomen and has two basal carinae extending about one-half its length and separated by a distance equal to one-half the width of the tergite; the remaining tergites each shorter than preceding one. The sternites are similar in size to the tergites. Each tibia has a dense patch of setae on the apical fifth on the posterior side. Only one tarsal claw is present and it is well developed. The metasternum is convex with a longitudinal median depression. The 8th, 9th, and 10th antennal segments form an indistinct club, each segment being wider than the preceding one.

A very interesting structure generally not mentioned in previous generic descriptions of *Decarthron* is the oval foveae on each side of the mesosternum (figs. 77 and 78) just anterior to the middle coxae. These foveae meet in the middle forming an oval hole through the mesosternum when viewed from the side. Ventromesad of this hole there is another fovea that connects with the lateral ones. All three foveae are covered with setae.

In *Decarthron* another peculiar structure is found on the head (fig. 81) just behind the antennal bases. On each side there is a rounded flap which is connected anteriorly to the head by a membrane. In cleared specimens this shows up very distinctly but even in uncleared ones it is distinguishable.

The males frequently have secondary structural characters such as modified middle and anterior femora (figs 87–95), modified antennae (figs. 74–76), or modifications of the front of the head (figs. 79, 80 and 82), and most of the Honduras *Decarthron* males have the following structures: apical spatulate spur on the anterior tibia (except *fractifrons* Fletcher, 1928, p. 217); apical spine on the middle tibia (except *fracti-*

frons); emarginate pygidium and eighth sternite; and modified eighth sternite (fig. 83), which is easily seen in cleared specimens, but can also be distinguished in uncleared ones; ninth sternite (fig. 102) consisting of two short cylindrical pieces generally remaining attached to the genitalia when the latter is removed. The eighth sternite has a lateral internal prolongation on each side extending anteriorly and ending in a broad flat lobe; near the center are two parallel rod-like projections originating from the base of the sternite; these projections extend anteriorly to a point just beyond the base of the seventh sternite.

The females generally have the pygidium and eighth sternite rounded apically, or at most very slightly emarginated; only a simple apical spur on the anterior tibia (except *fractifrons*); unmodified femora; and unmodified antenna (except *punctatum* Fletcher (1928, p. 221) which has the third, fourth, and fifth segments elongate).

Some of the groups defined by Raffray (1904, p. 185) are not natural phyletic units and their use should be discontinued. Park (1942, p. 186) continued the use of these groups by accepting Raffray's key which uses such characters as antennae "abnormal" or "normal" and intermediate antennal segments "cylindrical to obconic" as against "ovoidal, globular, or moniliform." If the use of these groups is continued by future workers, then closely related species might be inadvertently referred to different groups. For example, *yaguale* n. sp. and *castaneum* n. sp. are quite similar in respect to the anterior and middle femora and the genitalia, but according to Park's key, *yaguale* is in group 8 and *castaneum* group 9; also *cristatum* n. sp. and *armatum* n. sp. are similar in the modification of the front, the highly modified middle femur, and the antenna, but according to the previous grouping, these species belong in groups 6 and 14 respectively. For these reasons it is thought best to dispense with the groups as Raffray defined them.

KEY TO SPECIES

1. Pronotum with three basal foveae, two lateral and one median . . . **fractifrons**
   Pronotum with only a median basal foveae 2
2. Pygidium always emarginate, fitting into an emarginate eighth sternite; eighth sternite (fig. 83) always modified internally with two rod-like projections near the middle extended forward, the lateral edges curved forward and terminating in a broad flat lobe; middle femur (figs. 89–95) frequently modified; antenna (figs. 74–76) frequently modified; males . . . 3
   Pygidium generally rounded, may be slightly emarginate; eighth sternite simple or with a median tubercle; middle femur never modified; antenna unmodified (except in *punctatum* (fig. 73); females 10
3. Middle femur (figs. 89–95) modified, excavated and enlarged 4
   Middle femur unmodified, never excavated or enlarged 9
4. Middle femur (fig. 93) excavated anteriorly; acute spur just below the dorsal apex; dorsal apex with several setae in a group . . . . . **aguanensis**
   Middle femur (figs. 89–95 except 93) excavated posteriorly; generally with laminoid projection arising from the ventral edge 5
5. Anterior femur unmodified, not enlarged 6
   Anterior femur (figs. 87–88) modified, enlarged 8
6. Apical edge of excavation of middle femur (figs. 92 and 95) with conical or curved laminoid projection having a recurved tip 7
   Apical edge of excavation rounded, never projecting as above; femur (fig. 94) not highly modified . . . . . **truncatum**
7. Front (fig. 79) distinctly produced truncately; a curved laminoid projection at apical edge of excavation of the middle femur (fig. 95); antenna unmodified . . . . . **armatum**

Front not distinctly produced; conical projection of middle femur (fig. 92) at apical edge; antenna (fig. 75) modified..... **cristatum**

8. Anterior femur (fig. 88) abruptly narrowed just beyond the middle; middle femur (fig. 90) with dorsally curved spur slightly below the dorsal apex; prominent triangular projection on ventral edge of excavation; color light brown..... **castaneum**

Anterior femur (fig. 87) sloping gradually on apical half, with a flat, shining oblong area extending from the dorsal apex half way to the apex of the femur; middle femur (fig. 89) ventrally curved, truncate spur at the dorsal apex; dorsal side of excavation irregularly produced; ventral edge with slight carinoid ridge bearing several setae; color brown..... **yaguale**

9. Antenna (fig. 74) modified, third and fourth segments each very elongate; front not produced..... **punctatum**

Antenna (fig. 76) modified, third, fourth, and fifth segments produced mesally; front (fig. 82) roundly produced..... **confrente**

10. Antenna (fig. 73) modified, third and fourth segments each longer than any other except tenth..... **punctatum**

Antenna unmodified, third and fourth segments each not longer than any other except tenth..... 11

11. Front not produced, very similar to that of the male (as in fig. 81); only a few setae on front..... **aguanensis**

Front distinctly produced, although not as much as in males (see figs. 79 and 82); front quite hairy..... 12

12. Front roundly produced when viewed from the side (as in fig. 82); eighth sternite with a median tubercle internally..... **confrente**

Front angularly produced when viewed from the side (as in fig. 79); eighth sternite simple, without median tubercle..... **armatum**

Decarthron fractifrons Fletcher

Decarthron fractifrons Fletcher (1928, p. 217).

The males are characterized by having a modified front (fig. 80), the dorsal edges of the antennal fossae are carinated and meet straight across the front about one-half the distance from the antennal bases to the apex of the labrum; the ventral carinated edges of each fossa meet in a blunt point on the front just below the dorsal edge leaving a V-shaped notch in the front when viewed from the side. The first antennal segment is bluntly produced ventrally. There are two large deep lateral foveae on the pronotum in addition to the usual median fovea. The anterior and the middle tibiae are without apical spurs or spines. The genitalia (fig. 98) have a broad rectangular dorsal plate, and only two other lobes which are appressed tightly to the dorsal plate; the right and left lobes are nearly equal in size and slightly curved; the basal pieces are very long and curve dorsally enclosing the basal part of the genitalia; the median piece is solid with no opening in it as in the other *Decarthron* examined.

The females have a rounded notch on the front instead of a V-shaped one, and the dorsal and ventral carinae of the antennal fossae are almost obliterated across the front. The first antennal segment is not produced ventrally. The pronotum has three foveae. The eighth sternite is simple internally, without a median tubercle. The ninth sternite is narrow mesally and as long as eighth at the lateral margins.

Distribution.—This species was described from Vera Cruz, Mexico, and Park (1944, p. 238) recorded it from Guerrero, Mexico. Olanchito: June 20 (1 ♀), June 21 (2 ♂, 1 ♀), July 5 (1 ♂, 1 ♀), July 14 (1 ♀).

This is the only *Decarthron* now known from Honduras that has three foveae on the pronotum, all the others having only the median

fovea. The male genitalia are the most simple type of this genus as evidenced by the large basal pieces, solid median piece, and poorly developed right and left lobes.

Decarthron punctatum Fletcher

Decarthron punctatum Fletcher (1928, p. 221).

Male.—The antennal characteristics (fig. 74) readily separate this species from all other known Honduras *Decarthron.* The 3rd segment is longer than any other except the 10th, and is produced mesally; 4th nearly as long as 3rd; 5th produced mesally; 6th and 7th very transverse, produced mesally. The spatulate spur on the anterior tibia is deeply emarginate. The genitalia (fig. 100) are similar to those of *confrente:* the ventral plate is irregular; dorsal plate produced to the right at the base; two long setae on each of the basal pieces.

Female.—The female of *punctatum* has never been described, but four females were attracted to the lights which can be associated with this species. Front minutely punctulate. Antenna (fig. 73) with 2nd segment subquadrate; 3rd elongate, longer than any other except the 10th, with a very slight protuberance on the mesal surface; 4th shorter than 3rd, but still longer than any other except the 3rd and 10th; 5th subquadrate; 6th and 7th transverse, produced slightly mesally; 8th transverse, wider than 7th; 9th transverse; 10th ovoidal, depressed mesally on the apical half. Pronotum slightly wider than long, widest at the middle. The 8th sternite with a median internal tubercle seen clearly in cleared specimens. The 9th sternite divided mesally with a narrow triangular plate on each side. Metasternum with a very faint median depression.

Distribution.—The species has been recorded by Park (1944, p. 237) from Vera Cruz and Guerrero in Mexico. Olanchito: October 7, 1948 (1 ♂, 1 ♀) in light globe, June 20 (3 ♂, 1 ♀), June 21 (1 ♂, 2 ♀), September 8 (1 ♂).

The very elongate third and fourth antennal segments of both sexes readily separate *punctatum* from the other known Honduras *Decarthron.*

Decarthron confrente n. sp.

Male.—Length 2 mm., color light brown. Head longer than wide; vertex flat, with two foveae between the eyes; front (fig. 82) very

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EXPLANATION OF PLATE VII

FIGS. 73–76. *Decarthron* spp., antennae, dorsal aspect. 73. *D. punctatum*, female. 74. *D. punctatum*, male. 75. *D. cristatum*, male. 76. *D. confrente*, male.

FIG. 77. *Decarthron aguanensis*, mesothorax and metathorax, lateral aspect.

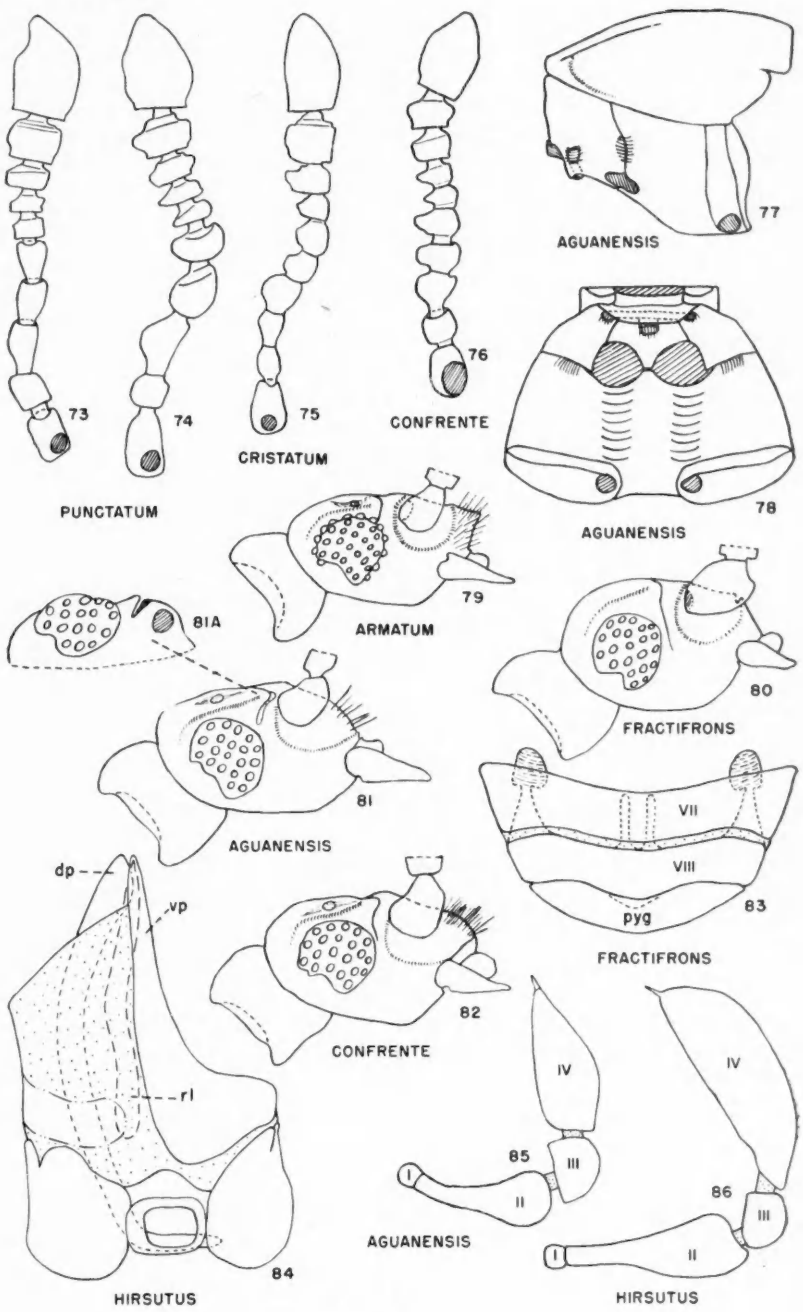
FIG. 78. *Decarthron aguanensis*, mesothorax and metathorax, ventral aspect.

FIGS. 79–82. *Decarthron* spp., head, lateral aspect. 79. *D. armatum*. 80. *D. fractifrons*. 81. *D. aguanensis;* A, oblique aspect. 82. *D. confrente.*

FIG. 83. *Decarthron fractifrons*, seventh and eighth sternites; *pyg* = *pygidium.*

FIG. 84. *Drasinus hirsutus*, male genitalia, ventral aspect; *dp* = dorsal plate, *rl* = right lobe, *vp* = ventral plate.

FIGS. 85–86. Right maxillary palpi, dorsal aspect. 85. *Decarthron aguanensis.* 86. *Drasinus hirsutus.*


73
74
75
76
CRISTATUM
CONFRENTE
PUNCTATUM
77
AGUANENSIS
78
AGUANENSIS
79
ARMATUM
81A
80
FRACTIFRONS
81
AGUANENSIS
VII
VIII
pyg
83
FRACTIFRONS
dp
vp
rl
82
CONFRENTE
IV
III
II
I
85
AGUANENSIS
IV
III
II
I
86
HIRSUTUS
84
HIRSUTUS

convex and overhanging the labrum, thickly covered with setae. Antenna (fig. 76) modified, with the 3rd, 4th, and 5th segments each produced mesally; 6th and 7th narrower on the mesal side than outer; 8th and 9th each quadrate, larger than preceding; 10th ovoidal, depressed mesally on the apical half. Pronotum transverse, widest in front of the middle. Metasternum convex with a broad shallow depression. Femora unmodified. Genitalia (fig. 104) with irregularly shaped ventral plate; dorsal plate and right lobe each curved inwardly; basal pieces large, each terminated with three long setae; median piece with a short projection on each side.

Female.—Similar to the male except the front is only slightly convex; antenna unmodified, fourth, fifth, and sixth segments quadrate; seventh slightly transverse; pygidium not emarginate; eighth sternite the same as in ***punctatum*** with a median internal tubercle (seen clearly in cleared specimens; ninth sternite very narrow mesally, nearly as long as eighth at the lateral margin; metasternum with only a slight depression.

Holotype male.—Olanchito, September 7. *Allotype* female, same data as holotype. *Paratypes*, 38 males, 24 females. Olanchito: October 7, 1948 (3 ♂, 14 ♀), in light globe, June 20 (8 ♂, 3 ♀), June 21 (16 ♂, 3 ♀), July 5 (1 ♂), July 6 (1 ♂), July 30 (4 ♂, 2 ♀), September 7 (1 ♀), September 8 (5 ♂, 4 ♀).

The male genitalia of ***punctatum*** (fig. 100) and ***confrente*** (fig. 104) are similar as to the dorsal and ventral plates, right lobe and basal pieces. However, these show some differences as illustrated. The females of these two species are the only two known Honduras *Decarthron* which have a small internal tubercle on the 8th sternite. Based on the type of male genitalia and the presence of this tubercle on the female eighth sternite, ***punctatum*** and ***confrente*** appear to be closely related phylogenetically, even though the antennae are quite different. The males of ***confrente*** can be distinguished readily from other known Honduras *Decarthron* by the overlapping front (fig. 82), the unmodified middle femur, and the produced third, fourth, and fifth antennal segments (fig. 76). The peculiar front separates this species from ***quadrifoveatum*** Fletcher (1928, p. 222) which has a declivious front. The third, fourth, and fifth antennal segments of ***quadrifoveatum*** are elongate, whereas in ***confrente*** all three of these segments are produced mesally. The females are very similar to ***aguanensis*** n. sp. and can be separated from them only by careful observation. The most obvious difference is the presence of the small internal tubercle on the eighth sternite of ***confrente***, this tubercle being absent in ***agaunensis***. This tubercle is easily seen in cleared material, but even in alcoholic

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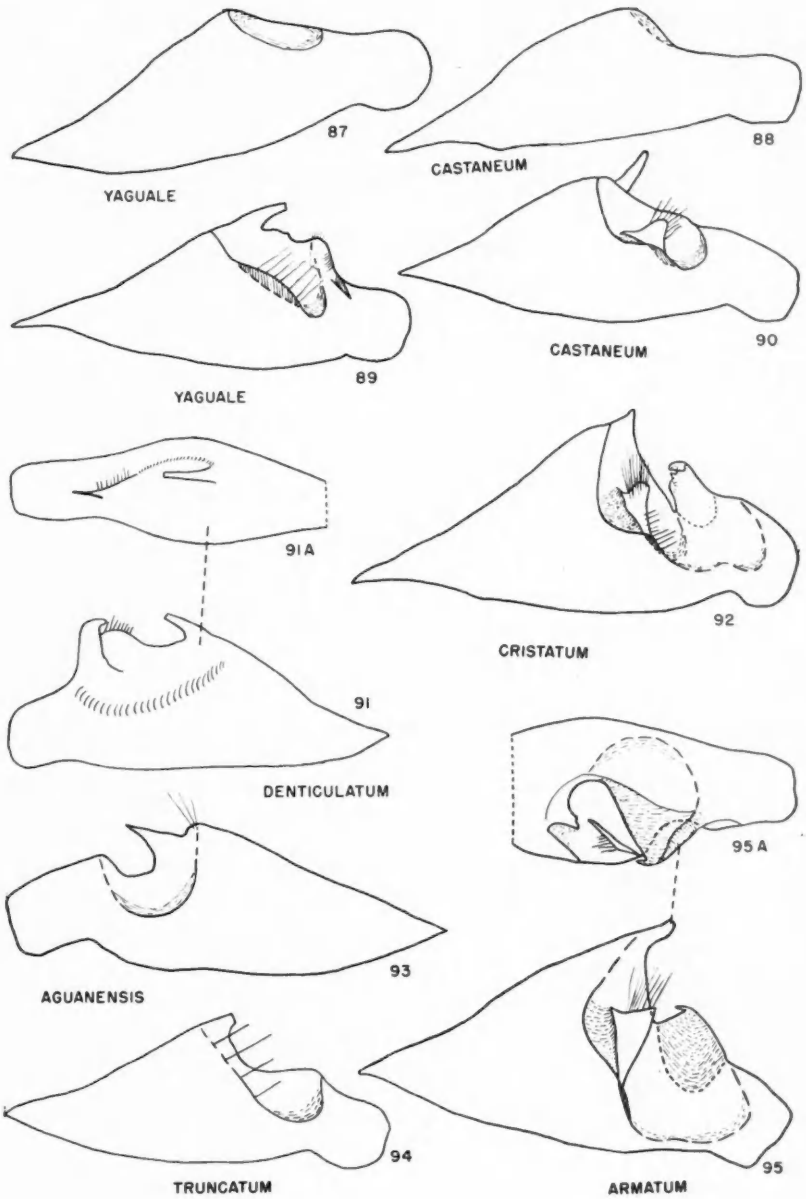
EXPLANATION OF PLATE VIII

Decarthron spp. FIGS. 87–88. Right anterior femora, lateral aspect. 87. *D. yaguale*. 88. *D. castaneum*.

FIGS. 89–95. Middle femora, lateral aspect. 89. *D. yaguale*, right femur. 90. *D. castaneum*, right femur. 91. *D. denticulatum*, left femur; A, dorsal aspect. 92. *D. cristatum*, right femur. 93. *D. aquanensis*, right femur. 94. *D. truncatum*, right femur. 95. *D. armatum*, right femur; A, dorsal aspect.


87
YAGUALE
88
CASTANEUM
89
YAGUALE
90
CASTANEUM
91A
91
DENTICULATUM
92
CRISTATUM
95A
93
AGUANENSIS
94
TRUNCATUM
95
ARMATUM

material it appears as a dark spot (not to be confused with the fecal material in the hind intestine). It cannot be seen in dry, uncleared material. The front in both sexes of ***confrente*** is quite hairy, much more so than in ***aguanensis***. In ***confrente*** females the dorsal and ventral surfaces of the head appear to be subparallel because of the produced front, and in ***aguanensis*** the surfaces appear to be slightly divergent due to the sloping front. The front of ***confrente*** females is slightly, but distinctly convex when viewed from the side, whereas in ***aguanensis*** the front is nearly straight from the base of the antenna to the labrum.

Decarthron aguanensis n. sp.

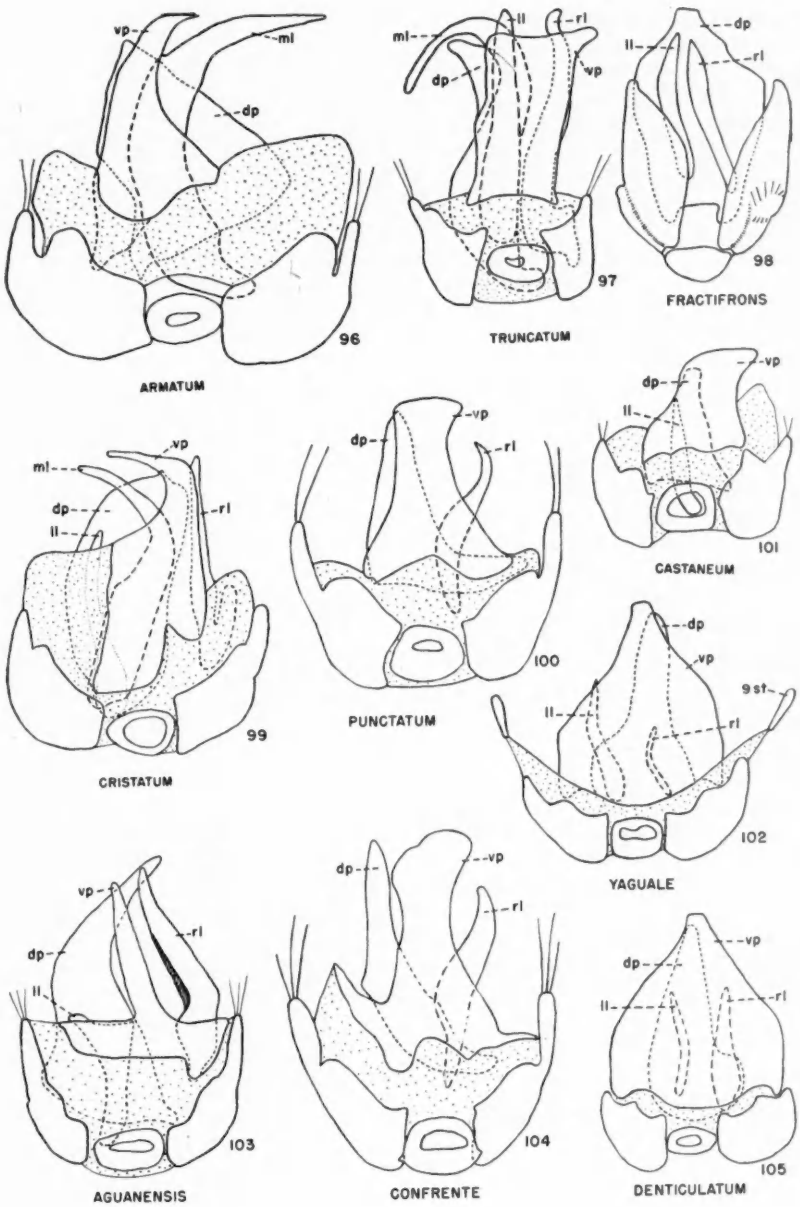
Male.—Length 2 mm.; color brown. Head elongate, one-third longer than wide; two vertexal foveae between the eyes; small median circular depression slightly posterior to the vertexal foveae; slight depression between the antennal bases; front (fig. 81) nearly straight from a lateral view, with a few scattered setae. Antenna unmodified; 2nd segment quadrate, 3rd widest at the apex, subquadrate; 4th slightly wider than preceding; subquadrate; 5th and 6th quadrate, slightly shorter than 4th; 7th transverse; 8th and 9th each widest at the apex, transverse; 10th distinctly longer than wide, widest at middle, apex bluntly pointed, apical half depressed on the mesal side. Pronotum wider than long, widest at the apical third; sides of basal two-thirds straight, then rounded to apex. Metasternum convex with a shallow median depression. Middle femur (fig. 93) modified; excavated anteriorly on the apical one-half with an acute spur originating slightly below the dorsal apex; dorsal apex with three setae. Anterior femur slightly modified by having a short, very small, longitudinal, dorsal carina on the median third of the apical half. Genitalia (fig. 103) with T-shaped ventral plate; dorsal plate and right lobes each curved inward; left lobe small; basal pieces each terminated with three setae.

Female.—Differs from the male by having an unmodified anterior and middle femur. The pronotum is widest at the middle. The pygidium and eighth sternite are each evenly rounded at the apex. The eighth sternite is simple without median internal tubercle, the ninth sternite narrow mesally and nearly as long as 8th sternite at the lateral margins.

Holotype male.—Olanchito, June 21. *Allotype female*, same data as holotype. *Paratypes*, 55 males, 51 females. Olanchito: October 7, 1948, (7 ♂, 11 ♀) in light globe, May 18 (1 ♂), May 24 (1 ♀), June 20 (15 ♂, 20 ♀), June 21 (8 ♂, 5 ♀), July 7 (1 ♀), July 14 (1 ♂), July 21 (1 ♂), July 30 (11 ♂, 9 ♀), August 24 (2 ♂), September 7 (2 ♂, 4 ♀), September 8 (2 ♂), and Cuidad Carmen, Campeche, Mexico, collected

EXPLANATION OF PLATE IX

FIGS. 96–105. *Decarthron* spp., male genitalia, ventral aspect; *dp*=dorsal plate, *ll*=left lobe, *ml*=median lobe, *rl*=right lobe, *vp*=ventral plate. 96. *D. armatum*. 97. *D. truncatum*. 98. *D. fractifrons*. 99. *D. cristatum*. 100. *D. punctatum*. 101. *D. castaneum*. 102. *D. yaguale*. 103. *D. aguanensis*. 104. *D. confrente*. 105. *D. denticulatum*.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96
ARMATUM
ml
ll
rl
dp
vp
97
TRUNCATUM
dp
ll
rl
98
FRACTIFRONS
ml
vp
dp
ll
rl
99
CRISTATUM
dp
vp
rl
100
PUNCTATUM
dp
vp
ll
rl
101
CASTANEUM
dp
vp
9st
ll
rl
102
YAGUALE
vp
dp
ll
rl
103
AGUANENSIS
dp
vp
rl
104
CONFRENTE
dp
vp
ll
rl
105
DENTICULATUM

by Dampf, No. 8390 (1 ♂), Dampf, No. 8396 (4 ♂). The Mexican paratypes are in Dr. Park's collection.

This species differs from *schmitti* Raffray (1904, p. 191) mainly in the form of the middle femur as illustrated. *D. schmitti* has an acute spur on the dorsal apex of the femur, and *aguanensis* has the spur just below the apex. *D. schmitti* has a tubercle on the anterior trochanter which is not present in this species. The female of *aguanensis* is very similar to that of *confrente* and for a comparison with it, see description of the latter species.

Decarthron yaguale n. sp.

Male.—Length 2 mm.; color light brown. Head longer than wide; two deep vertexal foveae between the eyes, vertex convex posterior to the foveae and depressed shallowly between the antennal bases. The 2nd antennal segment slightly elongate; 3rd elongate, widest at the apex; 4th, 5th, and 6th each transverse; 7th transverse, narrower and rounded on mesal side; 8th widest at the apex, subquadrate; 9th transverse; 10th ovoidal, depressed mesally on the apical third. Pronotum wider than long, widest at the apical two-thirds. Metasternum convex with shallow median depression. Anterior femur (fig. 87) enlarged at the middle, and with a smooth, oval flat area on the dorsal surface, the anterior edge of the area carinate. Middle femur (fig. 89) with a truncate, ventrally curved spur at the dorsal apex; dorsal edge of excavation carinated; ventral edge bearing several setae. Genitalia (fig. 102) with a triangular ventral plate; right and left lobes very small; basal pieces without setae.

Holotype male.—Olanchito, July 20. *Paratypes*, 15 males. La Ceiba: June 12 (2 ♂), August 26 (1 ♂); Olanchito: October 7, 1948, (1 ♂) in light globe, June 20 (2 ♂), June 21 (4 ♂), August 24 (2 ♂), September 8 (3 ♂).

This species keys to *schmitti* Raffray (1904, p. 191) in Park's key (1944, p. 260). However, it is very close to *denticulatum* Fletcher (1928, p. 224), and also it appears to be closely related to *castaneum* n. sp. *D. yaguale* has been compared with the holotype of *denticulatum* Fletcher, described from Vera Cruz, Mexico. The two species are very close in respect to the characteristics of the middle femora and the genitalia, but in all the other characters they appear to be indistinguishable. Since the sixteen specimens of *yaguale* show no apparent variation in these structures, it is believed that this species is distinct from *denticulatum*, which is known only from the type. The genitalia

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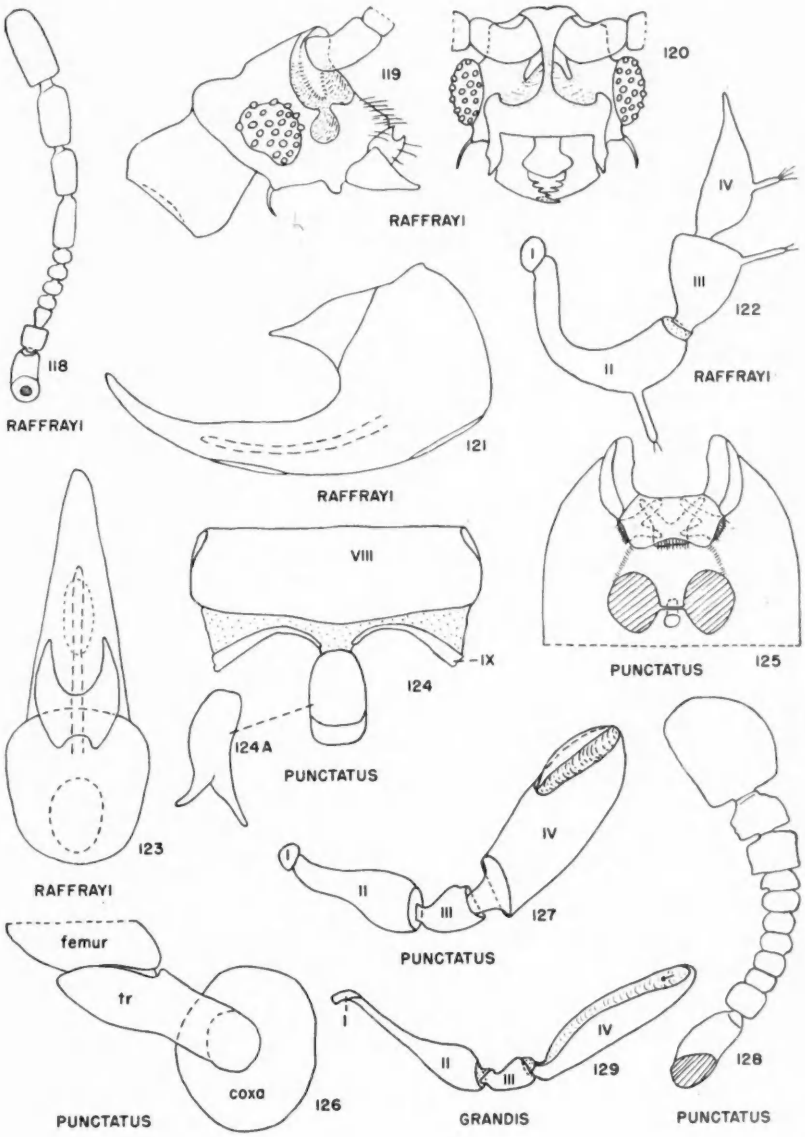
EXPLANATION OF PLATE X

Arthmius spp., males. FIGS. 106–108. Right antennae. 106. *A corradus*. 107. *A. torcerus*. 108. *A. curvicornis*.

FIGS. 109–111. Male genitalia, lateral aspect; *bl*=basal lobe, *bp*=basal piece, *lll*=left lateral lobe, *rll*=right lateral lobe, *ml*=median lobe. 109. *A. torcerus*. 110. *A. curvicornis*; A, ninth sternite. 111. *A. corradus*; A, ninth sternite.

FIGS. 112–113. Right anterior tibiae, lateral aspect. 112. *A. curvicornis*. 113. *A. torcerus*.

FIGS. 114–117. Heads. 114. *A. torcerus*, dorsal aspect. 115. *A. corradus*, dorsal aspect. 116. *A. torcerus*, lateral aspect. 117. *A. corradus*, lateral aspect.


118
RAFFRAYI
119
120
RAFFRAYI
IV
III
122
II
I
RAFFRAYI
121
RAFFRAYI
VIII
IX
124
124A
PUNCTATUS
PUNCTATUS
125
123
RAFFRAYI
IV
III
II
I
127
PUNCTATUS
femur
tr
coxa
126
PUNCTATUS
IV
III
II
I
129
GRANDIS
128
PUNCTATUS

of *yaguale* (fig. 102) have a large left lobe and smaller right lobe, and the dorsal plate is more angulated on the left side, but in *denticulatum* (fig. 105) just the opposite is true: the right lobe is larger than the left lobe, and the dorsal plate is angulated on the right side. Except for differences in the basal pieces and the median piece, these two genitalia are practically mirror images of each other. *D. yaguale* has a rounded laminoid projection on the apical part of the excavation of the middle femur (fig. 89) and there is a definite laminoid ridge with several setae on the ventral edge. This laminoid projection (fig. 91), shown in the illustration of the left femur, is deeply notched in *denticulatum* with the tooth curved towards the posterior face, and the ventral edge of the excavation is rounded without special setae.

The lack of a protuberance on the anterior trochanter and the presence of a truncate spur on the middle femur separates *yaguale* from *schmitti*. From *castaneum* it is easily separated by the form of the anterior and middle femora. The anterior femur of *yaguale* (fig. 87) is gradually sloping on the apical half, and in *castaneum* (fig. 88) it is abruptly sloping. The middle femur (fig. 89) of *yaguale* has a ventrally curving truncate spur on the dorsal apex, a carinated dorsal edge, and no triangular projection on the ventral edge, whereas *castaneum* (fig. 90) has a dorsally curved rounded spur, no carinated dorsal edge, and a triangular projection extending into the excavation. The genitalia of the two species also differ, *yaguale* (fig. 102) having a straight ventral plate, no setae on the basal pieces, and a small rod-like right lobe; and in *castaneum* (fig. 101) the ventral plate is curved, setae are present on the apices of the basal pieces, and there is no right lobe.

Decarthron castaneum n. sp.

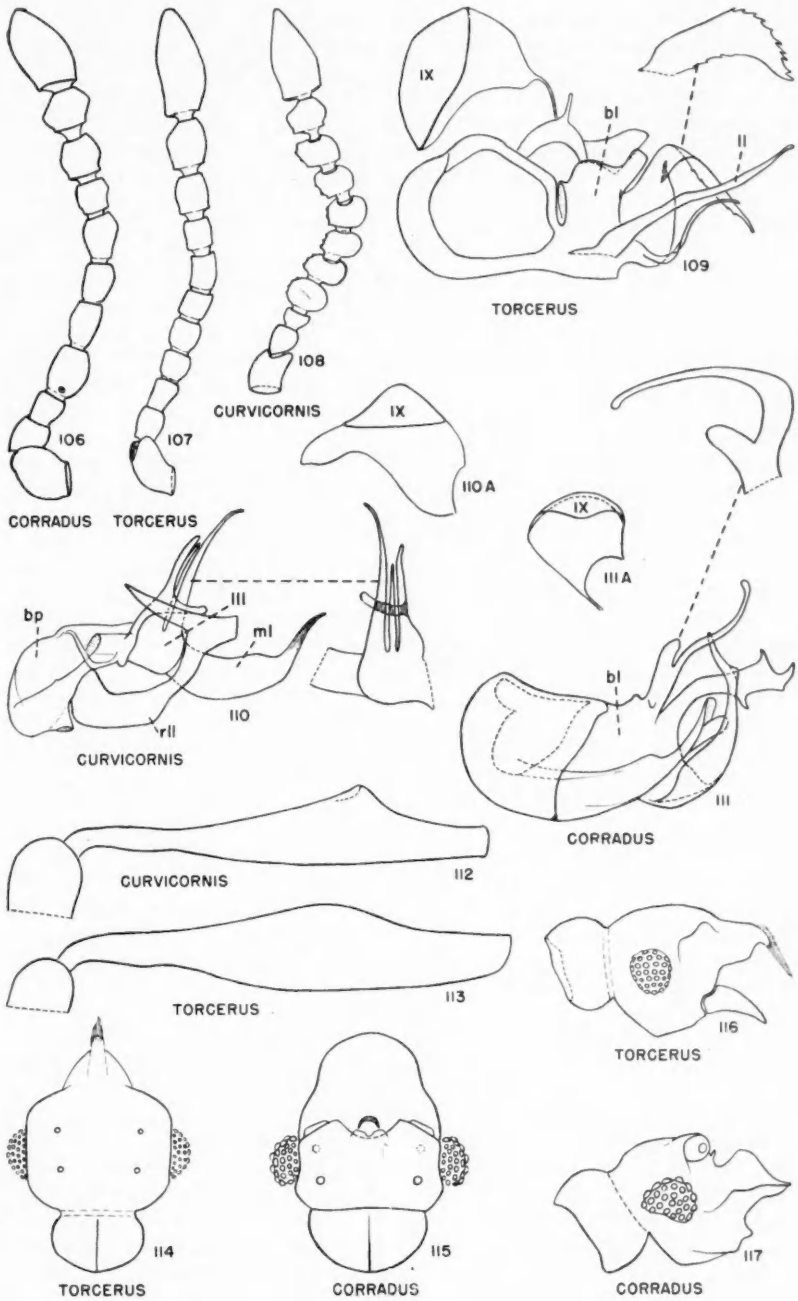
Male.—Length 2 mm.; color light brown. Head longer than wide; two deep vertexal foveae between the eyes; vertex flattened between the antennal bases, convex behind the foveae with a minute circular median depression just behind these foveae. The 2nd segment of antenna slightly elongate; 3rd elongate, widest at the apex; 4th slightly elongate; 5th, 6th and 7th each subquadrate; 8th subquadrate, widest at the apex; 9th subquadrate; 10th ovoidal, depressed mesally on apical half. Pronotum wider than long, widest at middle. Metasternum convex with a shallow median depression. Anterior femur (fig. 88) abruptly sinuate on the distal half. Middle femur (fig. 90) with a dorsally curved spur slightly below the dorsal apex; laminoid projection on the ventral side of excavation extending into it and bearing several

EXPLANATION OF PLATE XI

FIGS. 118–123. *Ctenisis raffrayi*. 118. Right antenna. 119. Head, lateral aspect. 120. Head, cephalic aspect. 121. Male genitalia, lateral aspect. 122. Right maxillary palpus, dorsal aspect. 123. Male genitalia, ventral aspect.

FIGS. 124–128. *Apharus punctatus*. 124. Eighth and ninth sternites and male genitalia, dorsal aspect; A, lateral aspect. 125. Mesothorax and metathorax, ventral aspect. 126. Right middle trochanter, ventral aspect. 127. Right maxillary palpus, dorsal aspect. 128. Right antenna, dorsal aspect.

FIG. 129. *Cercoceroides grandis*, right maxillary palpus, dorsal aspect.


106
CORRADUS
107
TORCERUS
108
CURVICORNIS
IX
bl
II
109
TORCERUS
IX
110A
bp
III
ml
rII
110
CURVICORNIS
IX
111A
bl
III
CORRADUS
CURVICORNIS
112
TORCERUS
113
116
TORCERUS
114
TORCERUS
115
CORRADUS
117
CORRADUS

setae. Genitalia (fig. 101) with ventral plate curved to the right; dorsal plate triangular; basal pieces each with two setae at apex.

Holotype male.—Olanchito, July 14. *Paratypes*, 16 males. Olanchito: October 7, 1948, (3 ♂) in light globe, June 21 (4 ♂), July 30 (6 ♂), September 8 (3 ♂).

This species is apparently closely related to *yaguale* and *lipovskyi* Park (1944, p. 237). *D. castaneum* differs from *yaguale* as discussed under the latter species. From *lipovskyi* it differs by having large vertexal foveae and a different type of middle femur. *D. lipovskyi* has a laminoid triangular tooth on the ventral surface of the excavation nearly beneath the apical spur, but *castaneum* has the projection considerably distad of the spur and extending into the excavation and not on the ventral edge. In *lipovskyi* the spur is curved dorsad and originates slightly below the dorsal apex of the femur; the excavation does not extend to the apex of the femur as illustrated in *lipovskyi* Park (1944, pl. 2, fig. 6).

Decarthron truncatum n. sp.

Male.—Length 2 mm.; color light brown. Head one-fourth longer than wide; two vertexal foveae between eyes; front sloping gradually. The 2nd antennal segment cylindrical, longer than wide; 3rd elongate, widest at the apex; 4th, 5th, and 6th each ovoidal, slightly longer than wide; 7th subquadrate, narrower mesally than on outer side; 8th and 9th each widest at apex; 10th ovoidal with a median depression on apical half. Pronotum wider than long, widest at the middle. Metasternum convex with a slight median depression. Middle femur (fig. 94) modified; excavated anteriorly on the apical one-half; truncate spur at the dorsal apex; ventral side of excavation bearing four setae. Genitalia (fig. 97) highly developed; ventral plate rectangular; median lobe curved strongly to the left; left and right lobes simple; basal pieces each bearing two setae at apex.

Holotype male.—Olanchito: June 20.

D. truncatum is described from a single male, distinct from the other known *Decarthron* in the form of the middle femur and genitalia. *D. truncatum* differs from *schmitti* Raffray (1904, p. 191) by not having a tubercle on the anterior trochanter, and by having a truncate spur at the dorsal apex of the middle femur.

Decarthron cristatum n. sp.

Male.—Length nearly 2 mm.; color light brown. Head longer than wide; two large vertexal foveae between the eyes; vertex convex; front truncate between the antennal bases and slightly produced. Antenna (fig. 75) modified; 2nd segment subquadrate; 3rd elongate, widest at the apex; 4th subquadrate, produced bluntly dorsally, wider than either adjacent segment; 5th and 6th each transverse, produced mesally; 7th transverse, shorter than 6th, produced mesally; 8th transverse, wider than apex of 9th, produced mesally; 9th subquadrate, widest at the apex; 10th ovoidal, depressed on mesal surface on the apical half. Pronotum nearly quadrate, widest just anteriorly of the middle. Metasternum convex with a broad shallow depression. Spatulate spur on the anterior tibia as long as the first tarsal segment.

Middle femur (fig. 92) deeply excavated on the apical half; dorsal apex with no distinct spur; apical end of excavation with a conical projection curving inwardly at the tip; laminoid projection extending from the ventral side towards the dorsal apex and thickly setaceous. Genitalia (fig. 99) with a broad ventral plate, curved to the left at the apex; dorsal plate rectangular; median lobe narrow, curved to the left; right and left lobes nearly straight; no setae on the basal pieces.

Holotype male.—Olanchito, September 8.

This species appears to be closely related to ***armatum*** n. sp. The form of the middle femur (fig. 92), the modified antenna (fig. 75), and the truncate, very slightly produced front will readily distinguish this species from ***armatum***. The middle femur of ***cristatum*** has a rounded laminoid ventral projection of the excavation; conical projection on the apical edge having a rounded tubercle near its apex, rounded apex recurved; short blunt spur at the dorsal apex. The middle femur of ***armatum*** has a pointed laminoid ventral projection; curved laminoid projection on the apical edge with acute recurved apex; longer blunt spur at the dorsal apex. The antenna of ***armatum*** is slightly modified and in ***cristatum*** it is modified as illustrated. Both species have a slightly enlarged fourth segment and the fifth to eighth segments are produced mesally.

Decarthron armatum n. sp.

Male.—Length nearly 2 mm.; color brown. Head longer than wide; two vertexal foveae slightly anterior to the middle of the eyes; front (fig. 79) truncately prolonged anteriorly between the antennal bases; the projected front dorsally devoid of pubescence and the pubescence on the sides curved mesally. Antenna slightly modified; 2nd segment slightly elongate, cylindrical; 3rd elongate, widest at the apex; 4th wider than either adjacent segment, subquadrate; 5th and 6th each subquadrate, slightly produced mesally; 7th transverse; 8th transverse, produced mesally; 9th transverse, widest at the apex; 10th ovoidal, depressed ventrally on the apical half. Pronotum wider than long, widest about the middle. Metasternum convex with a broad shallow groove. Anterior tibia with a long broad spatulate spur which is as long as the first tarsal segment. Middle femur (fig. 95) deeply excavated on the apical half, twice as long as broad; dorsal apex with a blunt spur; dorsal edge of the excavation with a thin curved laminoid projection; ventral edge with a triangular laminoid projection extending towards the dorsal apex. Genitalia (fig. 96) with an irregular ventral plate curved to right at the apex, median lobe curved to the right; dorsal plate triangular; basal pieces each with two setae at the apex.

Female.—Differs from the male by having the front not quite as produced; antenna unmodified, 2nd segment elongate; 3rd elongate, widest at apex; 4th elongate; 5th slightly elongate; 6th and 7th each subquadrate; 8th widest at the apex; 9th transverse, widest at the apex; 10th ovoidal, depressed mesally on the apical half; pygidium evenly rounded; the eighth sternite simple, without a median internal tubercle; ninth sternite the same length throughout, nearly as long

as the eighth; metasternum very slightly depressed; apex of the anterior tibia with a short spur; middle tibia with a short curved apical spine.

Holotype male.—Olanchito, June 21. *Allotype* female, Olanchito, June 20. *Paratypes*, 1 male, 7 females. Olanchito: June 21 (1 ♂), July 5 (1 ♀), July 30 (3 ♀), August 24 (1 ♀), September 7 (1 ♀), September 8 (1 ♀).

Because of the structure of the front, this species is similar to *frontale* Raffray (1904, p. 195), but it also shows close affinities to *cristatum*. The male of *armatum* differs from that of *frontale* by the form of the middle femur. In Raffray's illustration (1904, figs. 84 and 85), *frontale* has a single sinuate laminoid projection arising in the center of the excavation when viewed from above; whereas *armatum* has two laminoid projections, one of which is straight. The middle femur of *frontale* is slightly less than three times as long as broad, and in *armatum* it is twice as long as broad. For a comparison of this species with *cristatum*, see the discussion under the latter species.

Decarthron spp.

Twenty-two female specimens have not been associated with the males and must be set aside until more material is available. Quite possibly most of these belong to either *yaguale* or *castaneum* as these were the only *Decarthron* taken in Honduras in which several males were taken but the females are unknown. However, no satisfactory characters could be found to associate the unidentified females with the males.

Tribe **Batrisini**

Arthmius LeConte (1849, p. 91)

This is the largest genus of the tribe Batrisini in the Neotropical region and contains about one hundred described species. It was the only genus of this tribe attracted to the lights in Honduras, and males only of three species were taken. They all agree by having the fourth abdominal segment distinctly margined laterally, and with a longitudinal carina nearly half way between the lateral margin and the short basal carina. The ventral surface of the head is convex and without carinae. Each elytron bears three small basal foveae, and is without a dorsal stria. The pronotum is smooth with a transverse groove about one-fourth to one-third the median pronotal length from the base, the groove ending at each side in a small fovea. The sides of the pronotum are rounded to a point near the base then straight, and both sides are parallel for about one-fifth the pronotal length. The middle coxae are distinctly contiguous, with the mesosternal and metasternal projections widely separated. The posterior coxae are distinctly separated, with the median projection of the anterior margin of the third abdominal sternite extended beneath the posterior margin of the metasternum. Each tarsus bears two claws, one of which is very thin and inconspicuous, almost hair-like. The middle tibia has a broad apical spur. The ninth abdominal sternite is distinctly visible between the eighth sternite and the apically emarginate pygidium. The entire dorsum is shining, without distinct punctures, and with long thin erect hairs.

The three Honduras species have many differences as indicated in the key and descriptions, most of the specific differences being found in the head, antenna, and male genitalia. The genitalia are strikingly distinctive, as shown in the illustrations (figs. 109–111). A comparative study of this structure in the three species failed to definitely homologize the parts, and it is possible that some structures in the illustrations may be misidentified.

KEY TO SPECIES

1. Front of head (figs. 114 and 116) rather suddenly narrowed and produced, the produced apex very narrow when viewed from above, curved ventrad and bearing a dense brush of hairs; antenna (fig. 107) narrow at base, gradually enlarged distally beginning with ninth segment and without foveae; genitalia as in fig. 109 ..... **torcerus**
   Front of head subtruncate or emarginate; at least one antennal segment with a fovea or intermediate segments enlarged and tuberculate 2
2. Front of head subtruncate; anterior tibia (fig. 112) gradually enlarged from base for about three-fifths its length then suddenly declivous and emarginate on outer margin; antenna (fig. 108) narrow at base, the fourth and succeeding segments suddenly and nearly equally enlarged to apex, each of the intermediate segments with small tubercles on inner surfaces; genitalia as in fig. 110 ..... **curvicornis**
   Front of head (figs. 115 and 117) emarginate, the emargination with two short quadrate cusps; anterior tibia with upper and lower margins parallel in apical half; antenna (fig. 106) with the fourth segment enlarged and with a small fovea at base; succeeding four segments narrower than fourth, the last three segments enlarged; genitalia as in fig. 111 .... **corradus**

Arthmius torcerus n. sp.

Male.—Length, 2 mm. Head (figs. 114 and 116) wider between eyes than distance from basal constriction to base of fronto-clypeal projection; two distinct foveae between eyes, and a distinct impression above base of each antennal insertion, the impressions not connected; front of head suddenly prolonged into a narrow ventrally hooked projection (figs. 114 and 116), the apical curved margin bearing a dense group of yellow hairs. Antenna (fig. 107) a little longer than head and prothorax, slender to about the eighth segment, the last three segments gradually enlarged; some of the middle segments together slightly curved, the seventh longer than the sixth or eighth. The fifth abdominal sternite broadly impressed. Metasternum with a deep median longitudinal groove. Middle trochanter simple, without spines. Anterior tibia (fig. 113) with the outer margin gradually enlarged to about the apical two-fifths, then evenly rounded and narrowed to apex; inner apical third of apex slightly emarginate and provided with a large group of capitate hairs; front surface of tibia near middle somewhat flattened. Middle tibia more slender than anterior tibia, with a long spur continued evenly from the inside margin of the tibia; posterior tibia with a dense brush of hairs on inside of apical eighth. Basal lobe of genitalia (fig. 109) very large with the left lateral lobe modified to form a curved flat plate having the edges serrate, and with two additional lobes as illustrated; lateral lobe slender, nearly evenly narrowed from base to apex; ninth sternite nearly convex on anterior and posterior margins with a surface area only slightly larger than attached thinly sclerotized edges.

Holotype male.—La Ceiba, May 15. *Paratypes*, 15 females. La Ceiba: May 21 (1 ♂), June 7 (3 ♂), June 12 (1 ♂), June 16 (8 ♂), June 24 (1 ♂), August 26 (1 ♂).

This species is similar to the Brazilian *sus* Schaufuss (1887, p. 143) in the shape of the head, as illustrated by Raffray (1897, pl. 17, fig. 40), differing by having the sides of the head straight and not concave as in that species. It also appears to be related to *monoceros* (Sharp) (1887, p. 15) described from Yucatan, Mexico, but differs from the description of that species in several details. The body is uniformly colored, without the contrasting black head and abdomen as described for *monoceros*, the front of the head is produced in a forward and downward direction in *torcerus* and not upward as described by Sharp, and the 8th antennal segment is not prolonged and acuminate beneath as described for *monoceros*.

Arthmius curvicornis (Schaufuss)

Batrisus curvicornis Schaufuss (1872, p. 286).

This species is a member of group 3 of the genus (Park, 1942, p. 217). It is readily distinguished from *torcerus* by its unproduced front, the distinctly angled anterior tibia (fig. 112), and the enlarged intermediate antennal segments (fig. 108). The middle tibia is similar to that of *torcerus* but the apical spur is angled with the lower margin of the tibia instead of being more continuously curved. The posterior tibia has the apical two-fifths bearing hairs, but in *torcerus* the apical eighth only has hairs. Genitalia (fig. 110) with a narrower basal piece than in *torcerus;* left lateral lobe with an acutely trilobed process at the base of the aedeagus, one of the lobes bearing a secondary lateral perpendicular extension at middle; right lateral lobe well developed; median lobe very broad in basal two-thirds then rather suddenly narrowed and tapered to apex; ninth sternite triangular, the attached thinly sclerotized edges larger in surface area.

Distribution.—Park (1945a, p. 407) records this species as widely distributed in Southern Mexico occurring from sea level to 4500 feet. La Ceiba: June 2 (1 ♂), June 11 (1 ♂), June 16 (2 ♂), August 26 (1 ♂). Olanchito: June 20 (5 ♂), June 21 (1 ♂).

Arthmius corradus n. sp.

Male.—Length 2 mm. Head (figs. 115 and 117) strongly transverse between the eyes, width nearly 1.75 times the length from basal constriction to anterior margin of vertex; vertex with two foveae, each about half way between meson and eye, and on a line that would pass through posterior third of eye; front margin of vertex shallowly emarginate and with two short quadrate cusps at base of emargination; front of head, below front margin of vertex, with a short erect quadrate projection or cusp, and with clypeus very strongly raised and rounded in central area; clypeus broadly extended in front, the sides narrowing to the rounded anterior margin. Antenna (fig. 106) slightly longer than head and pronotum; 3rd segment slightly smaller than 2nd; 4th conspicuously longer and broader than 3rd or 5th, and with a small fovea on inside of base; 5th, 6th, and 7th each longer than wide,

all subequal in length; 8th shorter and narrower than 7th or 9th; 9th, 10th, and 11th segments together forming a club, each with many small tubercles over the entire surface. Transverse subbasal groove on pronotum with a small erect median acute tooth. The seventh sternite of abdomen broadly impressed. Middle trochanter without a spine but broad and densely hairy on the lower surface. Anterior tibia very simple, the upper and lower margins subparallel on apical half; middle tibia very similar to the anterior one with the apical spur continuous with the inner tibial margin; posterior tibia with a dense brush of hairs on inside of apical fifth, the inner margin beneath hairs very finely toothed. Metasternum with a distinct longitudinal groove. Basal lobe of male genitalia (fig. 111) with left lateral lobe bearing one ventral and two dorsal projections; an additional structure, apparently homologous with tri-processed appendage in *curvicornis*, in this species bilobed, one arm blunt, the other scythe-shaped or hooked; other parts of genitalia as illustrated. The 9th sternite about one-third or one-half the size of adjacent membranous area.

Holotype male.—Olanchito, June 21.

The antenna of this species appears to be simply constructed but the 4th segment is larger than either the 3rd or 5th and it has a small fovea at base. This condition places the species in Park's group 4 (1942, p. 222) considering also the absence of sexual modifications in the legs. In this group it appears to be related to *quadripunctatus* Schaufuss (1872, p. 274) from Mexico, and to *bituberculatus* Reitter (1888, p. 256) from Brazil, differing from both in having the 4th antennal segment larger than the 5th.

Tribe **Ctenistini**

Ctenisis Raffray (1890, p. 143)

This small genus contains about ten species. It is the only genus considered in this paper which has scales instead of hairs on many parts of the body. Each of the last three segments of the maxillary palpus (fig. 122) has a lateral projection.

Ctenisis raffrayi Casey

Ctenisis raffrayi Casey (1893, p. 503).
Ctenisis dispar (Sharp) (1887, p. 2). Raffray (1896a, p. 271). Misidentification.

Two specimens only were taken in Honduras and they have been compared critically with an Arizona specimen believed to be *raffrayi*.

Male.—Length 2 mm.; color light brown. Head (figs 119 and 120) slightly longer than wide; when viewed from above it is quite narrow at the basal constriction and there is no suture on the dorsum separating the cervix and the head; three large vertexal foveae, the two lateral ones between the eyes, the larger median one just behind the antennal tubercles; vertex flattened on top with a transverse sulcus connecting the vertexal foveae and extending to the lateral margins of the head; deep median sulcus from the anterior fovea to the transverse sulcus; very prominent antennal tubercles; prominent tubercle on each side of the front between the eye and the labrum; strong recurving ventrocaudal ocular spine. Maxillary palpus (fig. 122) with lateral projection

terminating in a few setae on the second, third, and fourth segments; second segment curved forward at a right angle, slender on the basal half, club-shaped on the apical half, third and fourth segments each longer than wide. Antenna (fig. 118) about one-half the length of the body, with all segments cylindrical, 1st elongate; 2nd quadrate, 3rd quadrate, widest at the apex; 4th to 7th each transverse, subequal; 8th to 11th forming an indistinct club; 8th about as long as preceding four segments combined; 9th shorter than 8th; 10th slightly longer than 8th; 11th longer than any other, apex very bluntly rounded. Pronotum wider than long, widest near the middle, base and apex the same width; sides curved from the base to the apex; thickly covered with scales on the lateral margins on the basal one-half giving the appearance that the sides of the pronotum are subparallel nearly to the middle; elongate median basal fovea. Two deep foveae on each elytron; both the sutural and dorsal striae extending the entire length of each elytron, each with a narrow glabrous area laterad of the stria; scales sparsely arranged in rows. Abdomen one and one-half times as long as the elytra, nearly cylindrical. The fourth to seventh abdominal segments each with a transverse basal groove thickly covered with scales originating from the anterior edge of the groove and also from the posterior edge of the segment, scattered scales on apical portion of the segment. The fourth to seventh tergites each shorter than preceding one, with a longitudinal groove near each lateral margin; pygidium with a very blunt median longitudinal ridge and emarginate at apex. The fourth and fifth sternites subequal in length; sixth, seventh, and eighth each shorter than preceding; eighth emarginate opposite that of the pygidium exposing the ninth sternite as a circular plate; a small lateral plate on each side of the ninth sternite visible if the pygidium is raised. Metasternum very convex with a broad deep median depression. Genitalia (figs. 121 and 123) with a long median lobe having an opening on the dorsal surface for a slender, rod-like structure, lateral lobes short, joined in the middle; basal piece more or less globular, not separated from the median lobe.

Distribution.—This species was described from a unique specimen from Tucson, Arizona. The specimens that Raffray thought were *dispar* were from Mexico. Superior, Arizona, July 11, 1949, H. K. Gloyd, at light (1 ♂). Olanchito: September 8 (2 ♂).

The genitalia and external features of the Honduras and Arizona specimens have been compared critically, and apparently there are no differences between them. Casey's original description of *raffrayi* included the following points which are different from the above description: (1) third to seventh antennal segments each small, moniliform, wider than long, (2) sides of the pronotum parallel to middle then feebly convergent to truncate apex which is three-fourths as wide as the base, (3) pronotal disk has three very densely pubescent subfoveate areas along basal margin, (4) abdomen nearly as long as elytra, (5) abdominal border strong, inclined, (6) antenna two-thirds as long as body, and, (7) length 1.65 mm.

The different methods of preservation and study probably accounts for these apparent differences. Casey described his species from a

pinned specimen and the above description was from material in alcohol. The flexibility of the abdomen could very well account for the difference in size, and the light reflecting from the scales might account for the discrepancies in the description of the antenna and pronotum. This shows the possible inaccuracies which may occur when small individuals are studied as dry mounts, all of which may be avoided if the material is studied in alcohol.

Tribe **Tyrini**

Apharus Reitter (1882, p. 129)

This is a small genus with about five species, and is here reported for the first time as occurring north of South America. The long middle trochanter (fig. 126) and the maxillary palpus (fig. 127) with a sulcus confined to the apical half of the fourth segment, will readily distinguish this genus. Actually this sulcus is confined to the apical half only when referring to the overall length of the segment and not to the side containing the sulcus. Park (1942, p. 297) does not state clearly in his key how to measure the sulcus. We have been unable to detect a palpal cone in the apex of the sulcus of the fourth segment of the maxillary palpus as illustrated by Park (1942, pl. 20, fig. 6) for the genus. Furthermore this species does not have a tooth on the anterior trochanter as described by Park (1942, p. 306) for all known males. In spite of these differences, this species readily keys to this genus in Park's key (1942, p. 297). It differs from *Hamotus* by having the palpal sulcus confined to the apical half of the last segment.

Apharus punctatus n. sp.

Male.—Length less than 2 mm.; color brown; yellowish pubescence, subdecumbent on the elytra, suberect on the abdomen. Head one-third longer than wide; two small vertexal foveae just behind a line through the center of the eyes separated by a distance equal to two-thirds the width of the head; eyes medium in size; vertex evenly convex behind the antennal tubercles; front very narrow between the antennal bases. Maxillary palpus (fig. 127) with second segment curved dorsally and gradually enlarged to the apex; a shallow sulcus on the apical half of the fourth segment (considering the overall length of the segment), an erect longitudinal laminoid projection extending almost the entire length of the sulcus. Antenna (fig. 128) with 1st segment long, cylindrical; 2nd transverse; 3rd to 6th each transverse, joined closely to the preceding; 7th and 8th each transverse, slightly wider than 6th; 9th transverse, considerably wider than 8th; 10th transverse, wider than 9th; 11th globular, slightly wider than long, truncate at the base. Pronotum one-third wider than long, widest at the apical third; large lateral basal fovea on each side; a small median basal fovea. Elytra one-third wider than long; two large basal foveae on each elytron; sutural stria complete; dorsal stria extending to the basal third; surface coarsely punctate, granulate. The fourth tergite and sternite each with a large basal fovea near each lateral margin. The fourth tergite longer than the rest of the tergites combined,

longitudinal sulcus on each side originating at the base near the side and ending at the lateral margin on the posterior margin of the tergite; fifth to seventh each gradually decreasing in length; pygidium evenly rounded. The fourth sternite as long as the others combined; fifth to eighth each decreasing in length. Metasternum with a rounded tubercle on each side between the middle and posterior coxae; a broad shallow longitudinal mesal depression; metasternum deeply and narrowly emarginate between posterior coxae. Posterior coxae separated twice as widely as the middle coxae. Mesosternum (fig. 125) with three foveae, each extending inward, forming a furca; each prong of the median furca extending between the arms of the lateral furca. Genitalia (fig. 124) very aberrant; base ovoid with broad flat dorsal and ventral lobes.

Holotype male.—Olanchito, November 29, 1948, taken in a rotting banana pseudostem.

This species if allied to *colombiensis* Park (1942, p. 306), but differs from it by the presence of a laminoid projection in the sulcus of the fourth segment of the maxillary palpus. There are many elytral punctures, seventh and eighth antennal segments evenly transverse, no triangular impression on the elytron, and fourth tergite slightly longer than all others combined. *A. colombiensis* has a palpal cone, a few large elytral punctures, seventh antennal segment transverse, triangular, eighth transverse, widest at the apex; a broad triangular dorsal impression from the outer elytral fovea to the basal third of each elytron; and fourth tergite not as long as the others combined.

Cercoceroides Raffray (1896, p. 137)

This small genus contains about five species and belongs to the tribe Tyrini and until now has been known only from South America. The two equal tarsal claws, pronotum without antebasal sulcus, a narrow sulcus on the maxillary palpus extending the entire length of the last segment, last palpal segment slender, elongate, oval in cross-section, and the fourth tergite only slightly longer than the fifth, are characteristics which separate this genus from the other genera of the tribe.

Cercoceroides grandis n. sp.

Female.—Length nearly 3 mm.; color dark brown; prominent pubescence, generally recurved forward on the abdomen and elytra, recurved on pronotum. Head nearly twice as long as wide; two large vertexal foveae in line with the middle of the eyes; large median foveae just behind the antennal bases; vertex nearly flat; large antennal tubercles; front narrowed between the antennal bases; eyes large, projecting prominently from the head. Maxillary palpus (fig. 129) with a long second segment, nearly as long as the fourth, slender on the basal half and club-shaped on the apical half; fourth with a narrow sulcus extending the entire length, short appressed bristle (palpal cone) within the sulcus just before the apex. Antenna with all segments cylindrical, covered with long stiff pubescence; 2nd subquadrate; 3rd shorter, narrower; 4th to 6th each shorter than 3rd, subquadrate; 7th and 8th each slightly transverse; 9th slightly elongate, wider than

8th; 10th transverse; 11th elongate, very obtuse at the apex, gradually enlarged to near the apex. Pronotum subquadrate, widest at the middle; large lateral basal fovea on each side, smaller median basal fovea. Elytra one-third wider than long, shiny, disc without punctures, margins coarsely punctulate; each elytron with two prominent foveae, an entire sutural stria, and a dorsal stria extending caudad for the basal two-thirds. The fourth and seventh tergites and sternites each with a transverse basal groove, a large fovea near the lateral margins in this groove, gradually decreasing in length; fourth to seventh tergites each with a sulcus between the fovea and the lateral margin and subparallel to the margin; pygidium slightly emarginate. The fourth sternite with two small mesal triangular projections, one on each side of the transverse basal groove; fifth similar to the fourth but with minute mesal projections. Metasternum deeply and narrowly emarginate between the posterior coxae, convex, with a broad shallow median longitudinal depression.

Holotype Female.—Olanchito, June 21.

This is the largest pselaphid known from Honduras. In Park's key (1942, p. 334) this species keys to either *germaini* (Raffray) (1890a, p. 213) which is known from Matto Grosso, Brazil, or to *laticeps* Raffray (1917, p. 489) which is known from Paraguay. However, each of these species is only 2.3 mm. long whereas *grandis* is nearly 3 mm. Aside from the difference in size and the great distance from Honduras to Brazil, this species differs only slightly from *germaini* and *laticeps*. *C. germaini* has a subquadrate head and an obsolete depression on the metasternum, whereas in *grandis* the head is twice as long as wide and the metasternum has a broad shallow depression. *C. laticeps* has the 6th antennal segment slightly transverse, and sparsely pubescent, whereas *grandis* has the 6th antennal segment subquadrate, and the pubescence is prominent.

The table on following page records all of the Pselaphidae taken in the two light traps at Le Ceiba and Olanchito. One additional species and several records from sources other than the light traps are included. They are arranged by tribes in the table with the number of each sex indicated.

SUMMARY

One species of Pselaphidae was previously recorded for Honduras, and 38 species are added in this report. Over 600 individuals were collected chiefly in two light traps located in different ecological situations at stations separated by a distance of about 50 kilometers in Northern Honduras. Each trap was operated intermittently for a total of 26 nights from May to September, 1949, one at La Ceiba for about 10 hours each night and the one at Olanchito for 4 hours. A total of 12 genera were taken which included 24 new species, and the known ranges of 14 other species were extended. Two genera, *Apharus* and *Cercoceroides*, previously known only from South America, were found in this collection. The females of four species, *Decarthron punctatum* Fletcher, *Reichenbachia appendiculata* Raffray, *R. bicuspida* Park, and *R. vinusqua* Park are described for the first time. A comparison of the collections from the two localities shows that 23 of the

	La Ceiba		Olanchito		Total
	♂♂	♀♀	♂♂	♀♀	
Tribe Pxyidicerini					
Bythinoplectus trapezodis n. sp.			2		2
Bythinoplectus carenado n. sp.			1		1
Bythinoplectus emargo n. sp.			1		1
Tribe Euplectini					
Rhinoscepsis bonita n. sp.	2				2
Actium concavum n. sp.			1		1
Tribe Brachyglutini					
Eupsenius rotundus n. sp.		1	2		3
Eupsenius angulosus n. sp.			1		1
Reichenbachia appendiculata Raffray	4	2	5		11
Reichenbachia bicuspida Fletcher [1] [2]	24	18	11	19	72
Reichenbachia parki n. sp.			6		6
Reichenbachia vinusqua Park	3	1			4
Reichenbachia sarcinaria (Schaufuss)	1				1
Reichenbachia reichei (Schaufuss)			3		3
Reichenbachia guatemalensis Fletcher	9	1	1		11
Reichenbachia blandura n. sp.[1]			1		1
Reichenbachia diversula Raffray[1]			1	2	3
Scalenarthus depressus n. sp.[1]			107	50	157
Scalenarthrus femoralis n. sp.	1		1		2
Scalenarthrus olanchitus n. sp.			6	9	15
Scalenarthrus torrus n. sp.	1				1
Scalenarthrus inflatus Fletcher	4		4		8
Scalenarthrus globosus Fletcher	7		3		10
Drasinus hirsutus Fletcher		1	1	6	8
Decarthron fractifrons Fletcher			3	4	7
Decarthron punctatum Fletcher[1]			6	4	10
Decarthron confrente n. sp.[1]			39	25	64
Decarthron aguanensis n. sp.[1]			51	52	103
Decarthron yaguale n. sp.[1]	3		13		16
Decarthron castaneum n. sp.[1]			17		17
Decarthron truncatum n. sp.			1		1
Decarthron cristatum n. sp.			1		1
Decarthron armatum n. sp.			2	8	10
Decarthron spp.				22	22
Tribe Batrisini					
Arthmius torcerus n. sp.	16				16
Arthmius curvicornis Schaufuss	5		6		11
Arthmius corradus n. sp.			1		1
Tribe Ctenistini					
Ctenisis raffrayi Casey			2		2
Tribe Tyrini					
Apharus punctatus n. sp.[3]			1		1
Cercoceroides grandis n. sp.				1	1
TOTALS	80	24	301	201	606
TOTALS FROM EACH LOCALITY	104		502		606

[1]Some were taken from a light globe.
[2]Some were taken by sweeping.
[3]Taken in rotting banana debris.

38 species were taken only at Olanchito, 5 species were found only at La Ceiba, and 10 species occurred at both localities. Only one of the 9 species of *Decarthron* occurred also at La Ceiba.

The foregoing species are treated systematically with keys to the genera and species, notes on their distribution are given, and 129 illustrations of generic and specific characters are included.

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"SPLENDEUR ET DIVERSITÉ DU MONDE DES INSECTES"

This was the title of an exposition held in Paris for several months during the summer of 1953. It was presented by the Museum National d'Histoire Naturelle on the ground floor of the new Botany building in the Jardin des Plantes. The occasion for the exhibition was the acquisition by the museum of the René Oberthur collection, largest private beetle collection and including five million specimens in twenty thousand large boxes. The exhibition consisted of three sections: the first based on the Oberthur collection, showing sample boxes of conspicuous beetles, publications and plates based on parts of the collection, other aspects of its history, as well as a number of early or rare works on entomology and historic notes, samples of manuscripts, correspondence, publications and photographs of several other French or other entomologists of the past. One wall was taken up with a huge diagram of the component collections of the Oberthur collection, indicating 25 major collections, among them those of Dejean, Bates, Thomson, Wollaston, von Harold, Chaudoir, Gory and Fleutiaux, and about three dozen secondary collections, including those of Lorquin, Chevrolat, Saunders, von Gebler, Schaufuss and Faldermann, and a map of the world showing the areas of field work of some of the important professional collectors, missionaries and others who contributed to the collection. The second section presented charts, specimens, models and notes on the general field of entomology, particularly classification and anatomy, and the third treated the relationships of insects with man, particularly disease-carrying insects, agricultural pests, and also social insects. An interesting adjunct of this extensive and well organized exhibition was the inclusion of several wall cages of living insects, including large tropical stick-insects, grasshoppers and others, kept at proper temperatures so that they were actively feeding and reproducing.—J. L. GRESSITT.

A PRELIMINARY REPORT ON DACETINE ANT STUDIES IN AUSTRALIA

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From August 1950 to December 1951 the author was engaged in a study of the Australian ant fauna under the auspices first of a Parker Fellowship from Harvard University and later of a United States Educational Foundation (Fulbright Plan) Fellowship, with interim aid from the Museum of Comparative Zoology and from Dr. P. J. Darlington, Jr. Within the larger plan for a general study of the Australian ants, a concentrated study of the tribe Dacetini was given particular attention. In view of the fact that group-by-group revisions of the Australian dacetines are presently in press or being prepared, detailed biological observations will be reserved for publication with the systematic treatment of the genera and species concerned. From the mass of data gathered, however, it appears that certain generalizations concerning dacetine biology may safely be drawn at this time.

This is especially true when extensive studies by Mr. E. O. Wilson on the North American dacetine genera are taken into account. Mr. Wilson's paper, based on separate studies and published separately in this issue, carries pertinent references to earlier work in the field.

TheDacetini form an aberrant and sharply distinct group belonging to the subfamily Myrmicinae, as is demonstrated by the structure of the abdominal pedicel and the male genitalia. They may be grouped into four recent subtribes, characterized as follows:

Dacetiti

Palpal formula, maxillary 5, labial 3. Worker and female with 10 segments in the antennal funiculus. Includes *Daceton* Perty (Neotropical, one species) and *Acanthognathus* Mayr (Neotropical, 3 species).

Orectognathiti

Palpal formula, maxillary 5, labial 3. Worker and female with 4 segments in the antennal funiculus; second funicular segment greatly elongate. Includes *Orectognathus* Fred. Smith (Australasian-Papuan, 9 or 10 species) and *Arnoldidris* Brown (Papuan, 4 species).

Epopostrumiti

Palpal formula, maxillary 5, labial 3. Worker and female with 3 or 5 segments in the antennal funiculus. Includes *Epopostruma* Forel, *Hexadaceton* Brown, *Mesostruma* Brown, *Alistruma* Brown, *Colobostruma* Wheeler, *Clarkistruma* Brown (Australian Region) and *Microdaceton* Santschi (Ethiopian Region), each genus with only a few species.

Strumigeniti

Palpal formula, maxillary 1, labial 1. Worker and female with 3, 4 or, usually, 5 segments in the antennal funiculus. Includes the vast majority of Dacetini, including the large and widespread genera *Strumigenys* Fred. Smith, *Smithistruma* Brown, the African genus *Serrastruma* Brown, and many smaller genera making up the residue of names not mentioned above.

The Australian Region is inhabited by representatives of three of these four subtribes, whereas no other major zoogeographical region is known to have more than two. Though Australia appears to have

fewer species than do some other major regions, it has a larger and more varied array of genera than does any other region. As it is clear that the four subtribes represent as many divergent phyletic lines, the advantages gained by making the present study in Australia are evident. It was hoped that the present study would provide comparative data that would help to explain the evolutionary background of the peculiar habit, observed in American genera of the Strumigeniti, of highly developed collembolan predation. The results obtained, at least for such comparatively large and primitive forms as those of *Orectognathus*, were totally unexpected.

Observations of varying completeness were made in the artificial nest and, wherever possible, in the field. The artificial nests used were of plaster, with glass tops, made and kept in "flat fifty" cigarette tins, so that they were readily portable on the longer trips. Unless otherwise mentioned, the observations were made on *feeding habits* of dacetine colonies secured from the Dandenong Ranges or from the eastern outskirts of nearby Melbourne, Victoria. In the feeding experiments, a wide range of arthropods was introduced into the artificial nests as soon as the ants had become established and at frequent intervals thereafter. The choice of potential prey included most of the groups employed by Wilson or corresponding Australian ones; Collembola of various families, *Campodea* spp., *Hanseniella* (Symphyla), termites, small millipedes and centipedes, small dipterous adults, beetle larvae and nymphs of Dermaptera, small spiders and a wide variety of mites. Japygidae were relatively scarce, and were used only in the case of the *Orectognathus* species most closely studied. Ant larvae were not introduced, as it was felt that the known behavior of both adult and larval ants regarding foreign larvae of the same or other species precluded the possibility of obtaining significant data through such introduction. Ants of other species at the adult stage were tried in all cases.

Field observations of feeding consisted mainly of watching the approaches to known nests of the epigaeic foragers for workers returning with prey. Practically all nests found were removed with the surrounding material and sorted in the attempt to find bodies of the prey in the brood chambers or elsewhere in the nest, but this method usually proved to have negative results or else was ambiguous in providing data, because of the disruption of the nests in opening and transporting them and also to the obvious abundance of live potential prey often observed *in situ* close to or even within the nest chambers as the latter were broken open.

Observations of feeding habits were made in the artificial nest, and for the most part supplemented by field observations, on the species listed immediately below. Several of these species are, as yet, unpublished, and so are indicated by the abbreviation "sp."

Orectognathiti

Orectognathus sp. (Common species in southeastern Australia, related to *O. versicolor* Donisthorpe.)

Epopostrumiti

Epopostruma spp. (Three apparently distinct and probably undescribed species fairly common in southeastern Australia.)

Alistruma sp. (One undescribed species widespread in the southeastern parts of Australia.)

Clarkistruma alinodis (Forel). (Observed in Victoria and southeastern Queensland.)

Strumigeniti

Strumigenys perplexa (Fred. Smith). (Widespread and common in southeastern and southwestern Australia; observations made in Victoria.)
Strumigenys australis Forel. (Observed in North Queensland.)

In determining the food preferences, the prey are placed in the usual "accepted" or "rejected" categories; the accepted prey is caught by the workers or females and placed on, among or near the larvae, and the latter then feed upon it. The rejected organisms are those, placed so as to directly confront the adult ants, which the ants ignore, avoid or attack, but which they neither carry into the brood chamber nor are observed to feed upon. In the case of the *Orectognathus* species, observed in the artificial nest, there occurred the only hint of a possible intermediate category. In this ant, the prey was usually attacked, killed and fed upon by the adult originally catching it and by a succession of other adults, both within and outside the brood chamber, but only rarely near enough to the brood so that the latter could feed upon the carcass. This is considered to represent incomplete acceptance of the prey due to disturbing factors in the artificial environment.

In all the forms of dacetines studied, the prey accepted was exclusively members of the collembolan families Entomobryidae, Isotomidae and Sminthuridae[1]. A wide variety of poduroid collembola produced not one single acceptance; rather, poduroids usually were ignored or definitely avoided, and none was ever attacked. Symphylans, campodeids and other relatively active arthropods either caused the ants to recoil violently on contact, or in rare cases, provoked them to a seemingly dilatory and timid, usually more or less ineffectual attack. Mites were generally ignored, and caused only languid antennal play when passing near the ants.

Field studies of *Strumigenys perplexa* and *Epopostruma* spp. found these forms commonly returning to the nest burdened with entomobryid collembolans or, in the case of the *Epopostruma*, with sminthurids.

Toward the end of the author's stay in Australia, he discovered that the workers and females of *Epopostruma* spp. and *Strumigenys perplexa* will feed on honey diluted with water, and that the former visit the extra-floral nectaries of certain plants, presumably for sugary substances. However, as no dacetine was ever observed to feed the larvae by regurgitation, feeding on sugary materials is considered to be a strictly adult habit, perhaps restricted to the more epigaeic foragers.

The important conclusion reached from the Australian observations is that, in the species observed, food delivered to and fed upon by the Australian dacetine larvae consisted only of Collembola of the groups named, though a wide choice of potential arthropod prey was offered. This is in substantial agreement with previously published observations on the American dacetines.

COMPARATIVE ECOLOGY OF AUSTRALIAN DACETINI

Aside from feeding habits, the species studied and listed above and others seen in the field, but not so thoroughly studied, showed inter-

[1]The family names are used in the broadest sense. No members of the family Neelidae were employed in the trials. Family identifications were made by the author unless otherwise noted.

esting variation in habitat preferences, foraging habits and other behavior that will be more intensively reviewed with the various revisionary papers to be published later. Some broad points may be considered here.

Habitat preferences. The species of *Orectognathus* are restricted to regions of high or fairly high rainfall. Those from Australia are confined to the eastern and southeastern regions in rainforest and sclerophyll forest down to the types intermediate in moisture conditions, such as are found near the base of the Dandenong Ranges and the approaches to the Otway Ranges in Victoria. Nests are built, according to species, either in rotten logs or in the soil under or beside half-sunken stones.

Epopostruma, so far as is known, nests in the soil and only rarely with a stone as cover; sites chosen are in eucalypt forest ranging from medium-dry types (Lofty Ranges, South Australia; Grampians Ranges, Victoria) to medium-wet types like the tracts between Melbourne and the Dandenong Ranges, or the western gullies on Arthur's Seat, Victoria. *Alistruma* nests in rotten wood, usually in wet sclerophyll or rainforest. *Clarkistruma alinodis* has been taken in moist or wet sclerophyll forest, often near or in clearings. On three occasions I took this ant, twice in the Dandenongs and once on Tamborine Mountain, southeastern Queensland, in each case under a stone also covering a flourishing nest of one of the common and dominant *Rhytidoponera* ("*Chalcoponera*") species, commonly infested with unpigmented entomobryid collembolans. I have not myself seen, nor do I know of other records definitely stating, that *Clarkistruma* species display any preference for nest sites near or in *Chalcoponera* nests except as indicated by my three collections, which, however, were all I made of this genus (*Clarkistruma*) during my stay. *Clarkistruma ellioti* (Clark), the only other species in the genus, is known only from the type collection, made on Mt. Arapiles, western Victoria, a very dry locality on which the vegetation at its most luxuriant could not be described as more than low, stunted woodland.

Hexadaceton frosti was not taken during my stay, and remains known only from the unique type. Through the courtesy of Mr. F. E. Wilson and Mr. N. Tindale, however, I have been able to locate more precisely the spot at which this ant was taken. This "N. Mecklenburg" was a German colony before the first war, and the name has now been changed to Putpayerta; the locality is in the surveyor's Hundred of Nuriootpa, on the North Para River, South Australia, and is agricultural country at present. Originally, it is presumed to have been covered with low-rainfall vegetational types, such as mallee scrub and savannah woodland. The original collector was J. O. Tepper.

A number of *Strumigenys* species were taken in Australia, including several undescribed species. All of these show definite affinities with Indo-Papuan groups, and there are more species in Queensland than in the remainder of the Australian states combined, facts which lead me to the conclusion that *Strumigenys* is a relatively recent immigrant into the island continent. Most of the species prefer to nest in constantly moist sites, particularly in or under rotten logs or under stones in tropical rainforest. *Strumigenys perplexa*, however, shows surprizingly wide tolerance with respect to nesting sites, and has been found in dry, open woodland in South Australia and western Victoria,

as well as in the dark, moist fern gullies in the hills east of Melbourne. Another species, undescribed, appears to be restricted to even drier habitats in mallee scrub and savannah forest in Victoria and South Australia, and still another to dry open forest in Queensland.

Of particular interest is a new workerless parasite, the first among the dacetines, and the first social-parasitic ant known from Australia, of which the female lives in the nests of *S. perplexa*. This parasite was collected at three separate localities and was observed in the artificial nest; it is a *Strumigenys* species, and apparently is closely related to *S. perplexa*.

Foraging activities. Striking differences were noted among the genera studied as regards foraging. The *Epopostruma* species ran over the ground at a comparatively rapid pace, appearing like small *Tetramorium* to the naked eye, and did not hesitate to forage on grass blades or on the foliage of low herbage. Their appearance and behavior was quite a surprize for one used to the slow-motion stalking of American Strumigeniti. The various *Orectognathus* species obviously differ among themselves in foraging, as at least one species was found on the foliage of low rainforest shrubs, while another was found in the center of a large rotten log. *O. versicolor* and the common Victorian species may forage nocturnally, as they have not been seen outside their nests during the daylight hours and do not seem to be well situated for hypogaeic foraging in their usual nest sites.

Alistruma has not been taken outside its rotten-log habitat, and it seems probable that it hunts within the galleries and crevices of the log. *Clarkistruma* has not been seen except under rocks with *Chalcoponera*. The *Strumigenys* species have not been taken in the open, but only under rocks, logs, dead leaves and other objects lying on the ground surface. Except for *Epopostruma*, body movements are very slow as observed in the North American dacetines.

Sexual phases and colony foundation. The sexual phases appear as adults in southeastern Australia during the summer months, beginning about the first week in January. In all the colonies observed, only males or females, never both, were produced. This agrees with the previously collected series, although the total number of times sexual phases have been taken intranidally *in the field* is too small to permit of generalizations about nest unisexuality except, possibly, in the case of *Orectognathus* sp. Mating probably occurs in most cases at the end of January or beginning of February, but no actual flight has been observed. Isolated females or several species have been found in the field in the process of nest founding. That the females forage actively during the initial period is indicated by the fact that females, both isolated and established in populous nests, of *Strumigenys perplexa* and *Epopostruma* spp. can and do hunt actively and effectively in the artificial nest. In the case of two species of *Epopostruma*, the females have been seen foraging from well-established nests in the field on several occasions. In the nest of one species of *Epopostruma* in Victoria, *winged* females were found in the early spring, though this species normally does not produce sexual phases as adults until summer. It is thought that the single case observed of winged females in the spring may indicate that virgin females are kept over from one season to the next in certain

cases, though this species was observed on so few occasions that even the normal course of production of sexes is not certainly established. With the maturing of the sexual brood, a worker brood also comes to maturity, although worker pupation seems to be a bit delayed in the species observed, so that worker imagoes appear, on the average, a little after the bulk of the sexual forms have gained their full color and left the pupal state. This worker brood (in Victoria) appears to be the chief or only worker brood produced during a given year, if development schedules drawn from a combination of artificial nest and field observations are correct. The larvae develop with extraordinary slowness in the artificial nest, but appear at any given time of the year to be at about the same stage of development as those taken in the field at that time. Developmental data, however, are considered to be incomplete because of frequent enforced interruptions of the observation periods.

Nest populations. The numbers of workers were roughly of the same order in all species closely studied. *Orectognathus* nests were usually a bit less populous, with 10 to about 80 workers per colony, than were those of *Strumigenys perplexa*, with 40 to over 200 workers. Other genera and species had populations of intermediate sizes. In *Orectognathus* nests, there was usually only a single queen, whereas *Strumigenys perplexa* usually had three to five queens, and the other species two or three.

DISCUSSION AND CONCLUSIONS

The conclusions as to feeding habits are that the three divergent lines represented by the Australian dacetines all follow the basic pattern, previously observed in North and South American strumigenite genera, of predation on entomobryid, isotomid and sminthurid Collembola. My observations fail to agree with those of Wilson, recently made, only in that I have not been able to induce any of the Australian species to accept any animal food other than Collembola of the families mentioned (*sensu lato*). In view of the phylogenetic considerations and the good agreement by all investigations that Collembola form the chief item of the diet in the American species, the cases observed by Wilson in which campodeids, mites and other non-collembolan prey were accepted and fed upon by the larvae may probably be considered as evidence of secondarily-acquired weaknesses in the strictness of the prey-specificity pattern. Collembolan predation is considered as the generalized pattern of behavior in the Strumigeniti, Epopostrumiti and Orectognathiti, although it is by no means suggested that the even more primitive Dacetiti will prove to hold strictly to this pattern when their habits become known. The Australian observations are original in showing that the workers of at least some genera will feed upon sugary substances, but this type of feeding is believed to apply only to the adults, since adult-larval trophallaxis has not been observed in any dacetine species to date.

Other observations, mainly ecological, show that the biology of the Australian dacetines is roughly comparable to that of the various North American species in respect to foraging (except for *Epopostruma* and epigaeic or subarboreal *Orectognathus* species), production of sexual forms in temperate areas, and nest populations. Nesting sites chosen

compare with those of the American species, except that certain Australian species show strong tendencies to adapt themselves to drier areas. This tendency to xeric adaptation, however, is present in all major dacetine faunas, but has not been recognized in most cases. The first workerless dacetine, a species of *Strumigenys*, was collected and observed in the artificial nest in circumstances leaving little doubt that it is a social parasite of *Strumigenys perplexa*.

ADDENDA

Shortly before receiving the proofs of this paper, Father Thomáz Borgmeier, O.F.M., Jacarepaguá, Brazil, notified me of the first report of predation by a member of the subtribe Dacetiti. He received from Dr. Helmut Sick, ornithologist, a worker specimen of *Daceton armigerum* (Latreille) with a male specimen of *Acanthocera longicornis* Fabricius, collected together by Dr. Sick on August 16, 1951, at Jacaré-acanga, Alto Tapajoz, Pará, in forest undergrowth. The *Daceton* had caught the fly by the abdomen in its mandibles, and although the fly vibrated its wings most vigorously, producing a loud buzz while trying to escape through flight, it was unable to rise away from the ant. The indications from this note are that *Daceton* will attack a variety of small, living insects. Dr. Sick made his collection on a "thin branch," presumably above the forest floor; this agrees with previous reports that *Daceton* forages arboreally, at least to some degree.

INTRODUZIONE ALLO STUDIO DELLA ENTOMOLOGIA, by Guido Grandi. Two vol., xxii+950 pp., 780 figs., and xvi+1332 pp., 1198 figs. Edizione Agricole, Bologna, Italy. 1951. Price, L. 18,00.

This ponderous work, with its more than two thousand quarto pages and its richness in illustration should take a place as one of the important texts in the field. The author, whose title is Professore Ordinario di Entomologia at the Università di Bologna, obviously intended it as a text in an "introductory" course which, following the European tradition, is considerably more intensive than is usual in the United States. It covers the general subject: anatomy and morphology, embryology, postembryological development, and ecology (vol. I, pp. 1–468), with a very brief mention of the relationship of insects to human welfare; the rest of the work is devoted to a discussion of insects by orders and families. There is no section on physiology, but physiological material is included in the part dealing with morphology and elsewhere. Insect paleontology, as such, is not given a systematic treatment, but is mentioned only cursorily. These omissions were probably regarded by the author as justifiably not a part of the basic "introductory" field, but rather, like the agricultural, medical, and veterinary phases, subject matter for more specialized courses.

The overall impression which one receives from perusing the book is good. The paper is of good quality, the margins moderately wide, and the printing clear and in good type; the illustrations are for the most part well chosen and well reproduced. The compilation was obviously done with care, and the documentation indicates that the author has kept well abreast of the important development of his science. In spite of copious documentation, however, there is no bibliography; is it to be published under separate cover? Also there is no index, except a very complete one to orders, families, tribes, genera and species, at the end, and a detailed table of contents at the beginning, of each volume.

The taxonomic classification is a relatively conservative one; in the reviewer's opinion, too conservative so far as the primitively apterous groups are concerned. In the Diptera, there is mixed usage of the Meigen 1800 and 1803 names. The various categories seem to be adequately characterized, in spite of the lack of keys. Examples are drawn largely, but by no means exclusively, from the European fauna.

The American entomologist who can read or wade through passages in Italian will find this a very useful reference work. The amount of labor that has gone into its compilation and synthesis is tremendous, and the acquisition of certain concepts and the development of some ideas found in the text will well repay the trouble taken to read a foreign language.—M. T. J.

EGGS OF FLOODWATER MOSQUITOES

II. Hatching Stimulus[1]

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Numerous investigators have attempted to find specific environmental conditions conducive to hatching of eggs of floodwater mosquitoes. From these investigations two general facts are well known, (1) that eggs of certain species usually hatch when submerged in their natural habitats during the spring or summer and (2) that at other times eggs may remain dormant through one or more periods of inundation only to hatch later. Many explanations have been advanced to explain this apparently erratic behavior. None of these adequately takes into account the fact that hatching of an egg depends not only on the presence of a proper stimulus but also on prior events leading to completed conditioning of the egg. Consequently other investigators have been unable to confirm previous data. It is not surprising, therefore, that a great variety of methods have been proposed for inducing hatching.

Proposals so far made may be grouped according to supposed modes of action. Numerous observers have attributed the stimulating property to physical changes such as agitation, alternating periods of submergence and drying, or low temperature. At intervals throughout the history of the investigations of hatching stimulants, potency has been claimed for chemicals of great variety. Crowding of eggs has been shown to be effective by at least one observer. As was the case with chemicals, the influence of microbes has been considered important in the total aspect of hatching.

Changes in the physical environment, if they aid hatching at all, affect conditioning of eggs and do not initiate hatching itself. The influence of low temperature and alternate wetting and drying are examples of such conditioning. The idea that agitation is of itself an adequate stimulus has appealed to several workers. Such reports seem to be based on claims made by Buxton and Hopkins (1927), Roubaud (1929), and Roubaud and Colas-Belcour (1945). Roubaud found that agitation was most effective when used on eggs during the 8–10th day after a period of rest. Unfortunately, nothing is said about the composition of the medium used.

The addition of various chemicals to media surrounding eggs has been said to effect hatching. The list includes, among other things, such varied substances as acids, alkalis, sodium hypochlorite, hydrogen

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peroxide, potassium permanganate, alcohols, sugars (Roubaud, 1929); amino acids, milk, extracts from oats and beef liver, putrecine, urea, potassium acetate (Gjullin, *et al.*, 1939); glycogen, rice starch, vitamin C, pyrogallol, thioglycollic acid, hydroquinone, and sulfurous acid (Gander, 1951) and (Geiger and Gander, 1949); ether vapor (Roubaud, 1919) and extracts of catalpa wood (Gander, 1951). Some hatching of conditioned eggs almost always occurred in contaminated infusions of complex organic materials. Indoleacetic acid and related compounds gave erratic stimulation or none at all unless glucose was added to the medium, (Abdel-Malek, 1948, and Horsfall, 1949). Also tried were the proteolytic enzymes pepsin, trypsin, and papaine (Roubaud and Colas-Belcour, 1927).

Thomas (1943) observed the effect of crowding on hatching of eggs (*Aedes aegypti*) kept under sterile conditions. He found that a negligible number of eggs hatched unless there were seven or more eggs in each tube. For example, tubes containing one egg each yielded larvae from 6 percent of the eggs within 5 days while those containing 7 to 11 eggs produced larvae from 53 percent. Tubes containing as many as 53 eggs produced larvae from 83 percent of the eggs.

The possible role of bacteria was investigated by Bacot (1917), Atkin and Bacot (1917), Roubaud and Colas-Belcour (1929), Young (1922), Barber (1928), Rozeboom (1934), Thomas (1943), and by Gjullin, Hegerty, and Bollen (1941). All except Barber found that (1) bacteria seemed to stimulate hatching to some degree or (2) eggs whose surfaces had been sterilized failed to hatch until bacteria or other microbes were introduced into the medium. It is significant that none of these workers could obtain a consistently high percentage of hatch.

The inconsistent results in the literature suggested that some important variable was uncontrolled in the experiments reported. On the basis of preliminary experiments and the evidence presented in the papers cited above we were led to investigate the stimulation of hatching by bacteria and ultimately by chemical agents which remove free oxygen from the medium. Early experiments like those of our predecessors yielded negative or equivocal results. ***Only when we came to realize the importance of using properly conditioned eggs were we able to repeat our observations at will.*** The results obtained using various hatching stimuli on conditioned eggs free from soil and debris are presented in this paper.

METHODS

Bacteria on the surfaces of eggs were killed by immersing the eggs in 1:1000 Roccal[3] for 30 minutes at room temperature. The eggs were then transferred with a pipet to culture tubes where they were washed twice with buffer in order to free them of the sterilizing agent. About 8 ml of sterile 0.02 M phosphate buffer, pH 7.0, were added to each tube, and this supernate was withdrawn by suction through

[3]Roccal, a product of Winthrop-Stearns, Inc., is a mixture of alkyl quarternary ammonium compounds and is a cationic type of surface-active agent containing 10 per cent alkyl dimethyl ammonium chloride. The alkyl groups range from C_8 to C_{18}.

a pipet. Aseptic precautions were used throughout. Surfaces of the eggs were sterilized without impairing viability. Treatment with 1:1000 Roccal freed them of all bacteria and molds capable of growing under the experimental conditions. Nutrient broth added to eggs showed no evidence of microbial growth in 6 days when the eggs were treated with dilutions of Roccal up to 1:6000. When dilutions of 1:8000 or higher were used, growths of molds or bacteria were evident in 2 or 3 days. That this exposure to Roccal did not affect the viability of eggs is shown by the fact that 30 of 35 or 86 percent of treated eggs of *Psorophora confinnis* hatched as compared to 24 of 27 or 91 percent of untreated ones subjected to the action of bacteria in nutrient broth. In addition we consistently and repeatedly obtained hatching of 90 percent or more of the sterilized eggs of *P. confinnis* and *Aedes aegypti* used in experiments with various hatching stimulants.

The general procedure used in tests for hatching was as follows: Eggs were placed in culture tubes and appropriate amounts of buffer and reagents were added to give a total volume of 5 ml. The tubes were immersed in a water bath held at 26.5° C. The number of larvae present was recorded at intervals of 1 to 5 minutes for the first 30 or 40 minutes and at convenient intervals thereafter. After 24 hours the contents of each tube were examined under a dissecting microscope. Larvae were recounted, and all unhatched eggs were broken open to check the condition of the embryos. In cases where embryos were obviously nonviable as indicated by partial autolysis, they were not included in the totals.

The ability of bacteria to stimulate hatching of eggs of floodwater mosquitoes was tested by adding appropriate suspensions of bacteria to eggs whose surfaces had been sterilized. The culture used in most of the experiments was that of a representative of the *Pseudomonas fluorescens* group. It was isolated from stock eggs deposited on moist cellucotton. Our experiments confirm the findings of other workers that other species of bacteria are equally effective in providing the hatching stimulus for conditioned eggs. The culture was grown in Difco nutrient broth for 18 to 24 hours at 30° C. on a shaker. The bacteria were removed by centrifugation, washed twice with sterile phosphate buffer and diluted to an optical density of 1.0 (Lumetron colorimeter, Model 400, red filter). For the test 0.5 ml of this suspension was added to 4.5 ml of buffer or broth on the eggs.

In testing the ability of chemical agents to stimulate hatching, fresh solutions were made up for each experiment.

Hydrogen or nitrogen was led into the experimental tubes through glass tubing drawn to a point. The point was placed about 1 cm below the surface of the test solution so that the eggs would not be disturbed mechanically by the bubbling. Gas was passed through at the rate of about three to five bubbles per second. The nitrogen used was freed of oxygen by passing it over reduced copper in a modified Kendall tube, Savage and Ordal (1940).

A number of species of eggs were subjected to hatching experiments. Those cited herein were *Psorophora confinnis* and *Aedes aegypti*. Others that were induced to hatch after proper conditioning included *Aedes vexans*, *A. dupreei*, *A. trivittatus*, *A. stimulans*, *A. canadensis*, *Psorophora discolor*, *P. horrida*, *P. ferox*, *P. varipes*, *P. howardii* and *P. ciliata*.

RESULTS

Chemical removal of O_2.—Data obtained when cysteine and ascorbic acid were added to media containing eggs of *Aedes aegypti* are presented in Tables I and II. These results extend the findings of Gjullin *et al.* (1941) and Gander (1951). When properly conditioned eggs are used, hatching is regularly initiated in 2×10^{-3} M cysteine. Below this concentration hatching was not complete, and cysteine at 4×10^{-5} M has virtually no effect. With ascorbic acid the minimum effective concentration was 6×10^{-5} M while half this concentration did not bring about any hatching.

TABLE I

EFFECT OF VARIOUS CONCENTRATIONS OF CYSTEINE ON THE HATCHING OF CONDITIONED EGGS OF *Aedes aegypti*

MEDIUM	NUMBER OF EGGS PRESENT	EGGS HATCHED	
		Number	Percent
Sterile buffer	39	0	0
0.002 M cysteine	39	37	95
0.0004 M cysteine	39	27	69
0.0002 M cysteine	40	8	20
0.00004 M cysteine	40	2	5

TABLE II

EFFECT OF VARIOUS CONCENTRATIONS OF ASCORBIC ACID ON THE HATCHING OF CONDITIONED EGGS OF *Aedes aegypti*

MEDIUM	NUMBER OF EGGS PRESENT	EGGS HATCHED	
		Number	Percent
Sterile buffer	39	0	0
0.002 M cysteine	39	37	95
0.003 M ascorbic acid	40	39	98
0.0006 M ascorbic acid	20	20	100
0.0003 M ascorbic acid	38	34	89
0.00006 M ascorbic acid	20	20	100
0.00003 M ascorbic acid	20	0	0

Physical removal of O_2.—Hydrogen gas when bubbled through a medium containing eggs caused changes sufficient for rapid and effective hatching of eggs as is seen in Table III. As is the case with other stimulators, this one caused hatching to be completed within 30 minutes after the gas was admitted to the system. Gjullin *et al.* were able to hatch only some 25 percent of eggs so treated. Possibly differences in conditioning of the eggs account for this apparent difference in the effectiveness of this means of removing dissolved oxygen.

As a check on the specificity of the process we also performed the experiment with nitrogen. This gas is also an effective hatching stimulant as is shown by the data in Table IV. Note that when air was bubbled through the solution there was no hatching. When the air was replaced with nitrogen in the same tube, hatching began within 20 minutes and went to completion.

Some hatching takes place in freshly boiled and cooled buffer or nutrient broth. Because of technical difficulties, it is not easy to obtain consistent results. Small and variable amounts of oxygen were introduced into the solution when the eggs were added.

TABLE III

EFFECT OF HYDROGEN GAS ON THE HATCHING OF CONDITIONED EGGS OF *Aedes aegypti*

TREATMENT	NUMBER OF EGGS PRESENT	EGGS HATCHED	
		Number	Percent
Sterile buffer	50	1	2
0.002 M cysteine	20	20	100
Buffer, hydrogen bubbled through	65	58	89

TABLE IV

EFFECT OF NITROGEN GAS ON THE HATCHING OF CONDITIONED EGGS OF *Psorophora confinnis*

TREATMENT	NUMBER OF EGGS PRESENT	EGGS HATCHED	
		Number	Percent
Sterile buffer	19	0	0
0.002 M cysteine	20	19	95
Buffer, nitrogen bubbled through	80	80	100
Buffer, air bubbled through	19	1	5
Same tube, air replaced by nitrogen	18	17	94

Biological removal of O_2.—In a typical experiment using conditioned eggs of *Aedes aegypti* none of 40 eggs kept in sterile nutrient broth hatched in 24 hours. In similar tubes to which bacteria were added, 85 of 88 eggs hatched, most of them within 60 minutes. Dilution of the baterial suspension 1:5 increased the time required for complete hatching to about 90 minutes. With further dilution hatching was delayed for several hours.

Concentrations of reducing agents which bring about rapid hatching in relatively simple media such as nutrient broth or buffer have little or no effect on eggs in complicated media such as submerged leaf mold on soil. However, when such a complex medium was placed under

conditions favorable to rapid microbial growth, hatching of conditioned eggs proceeded to completion.

It is clear from the data presented that rapid and complete hatching of conditioned eggs may be expected in environments where the concentration of dissolved oxygen is lowered by chemical, physical, or biological means. In light of this evidence it is of interest to consider reports in the literature. The majority of investigators either did not use sterilized eggs or did not specify the conditioning treatment applied to the eggs. Wherever aseptic conditions were maintained all media that induced hatching were ones in which the concentration of available oxygen was reduced in the immediate vicinity of the eggs. In addition hatching generally occurred in contaminated organic infusions or other solutions capable of supporting bacterial growth. When using such media aseptic precautions must be taken if stimulation by chemical agents is to be distinguished from the stimulation which results from removal of oxygen by microbial respiration. In the natural habitat, aerobic microbes probably are responsible for reduction of oxygen to such a level and for such a time that permits hatching of the eggs.

This effect of oxygen is a singular one. It is remarkable that an aerobic organism should be stimulated to abandon its resting stage under anaerobic conditions. It is to be hoped that investigations of this phenomenon in terms of the biochemical processes involved will yield a rational explanation.

SUMMARY

1. Factors affecting the hatching of eggs of several species of floodwater mosquitoes were investigated. *Psorophora confinnis* and *Aedes aegypti* were used in experiments cited herein.

2. When properly conditioned, bacteria-free eggs hatched rapidly and completely in the presence of reducing agents such as cysteine (2×10^{-3} M), and ascorbic acid (6×10^{-5} M or greater).

3. Removal of dissolved oxygen by bubbling hydrogen or nitrogen through the medium likewise resulted in rapid hatching of conditioned eggs.

4. Addition of suspensions of living bacteria to sterile eggs brought about rapid hatching presumably through removal of dissolved oxygen by the microbes.

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BULLETIN OF THE CALIFORNIA INSECT SURVEY. University of California Press, Berkeley and Los Angeles.

The organization of the California Insect Survey is of recent date, but its activities have been very heartening. One result is the development of collections that promise to become important at the University of California on the Berkeley, Davis, and Los Angeles campuses, where, only a few years ago, collections existed for instructional purposes alone. Another is the publication of the *Bulletin of the California Insect Survey*, the first number of which appeared as of June 30, 1950. I have received six numbers of volume 1 and two of volume 2. These cover the Tabanidae, by W. W. Middlekauff; the Culicidae, by S. B. Freeborn and R. M. Bohart; the Rhipiphoridae, by E. G. Linsley and J. W. MacSwain; *Dasymutilla* of the Mutillidae, by Paul D. Hurd, Jr.; the Melectini (Anthophoridae), by P. D. Hurd, Jr. and E. G. Linsley; the Scoliidae, by Paul D. Hurd, Jr.; the Eriophyidae (Acarina), by H. H. Keifer; and the Itonididae, by A. Earl Pritchard.

Publication is by offset process, on 8½ by 11 inch pages, stapled, double column. A gradual general improvement has been made in the printing, with the result that there is a decided contrast between the mimeograph-like appearance of the first number and the much more easily usable form of the last two, with their better type and varied, more outstanding headings. A similar plan is followed throughout: keys are given to supraspecific categories and, where practicable, to species; distribution is given by California localities arranged by counties. Descriptive material and taxonomic discussion is kept to a minimum. Hosts, original references, and important bibliographic references are given. All numbers are illustrated by one or more plates each, Mr. Keifer's paper being especially noteworthy in this respect, with its fifty pages of closely placed, detailed illustration. The price for the eriophyid paper is $2.00; the others range from 25 to 50 cents each.—M. T. J.

THE ECOLOGY OF SOME NORTH AMERICAN DACETINE ANTS

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INTRODUCTION

The tribe Dacetini is composed of a moderate number of unusual forms characterized by a tendency toward extreme reduction in the number of antennal segments, elaboration of the apparently predacious mandibles, and development of a wide diversity of types of bizarre cephalic hairs. It has recently been intensively revised by W. L. Brown (see 1948, 1949 for major changes), who finds that it is predominantly tropical and contains several large, abundant genera plus a quantity of small, very poorly known ones. Some of the larger genera have penetrated temperate zones and one at least (*Smithistruma*) has undergone considerable speciation there. Phylogenetic trends as outlined by Brown (1948 and *in litt*)[1] include reduction in size, shortening of the mandibles, and a shift from an epigaeic to a hypogaeic mode of life. All of the forms found thus far in the United States belong to four dominant, relatively specialized genera. *Strumigenys* F. Smith is represented by one species, *S. louisianae* Roger, extending from tropical America into the southern states. *Trichoscapa* Emery is also represented by its single species *T. membranifera* Emery, a tropicopolitan tramp which has been collected frequently in the Gulf States. *Quadristruma* Brown is known at this time in the United States from a single record of *Q. emmae* (Emery) from Homestead, Florida; it has probably been introduced. *Smithistruma* Brown is represented by no less than 22 endemic and one possibly introduced species. These are found over the entire United States but are very scarce west of the Mississippi and in the extreme north. Even though it tends to be replaced by *Strumigenys louisianae* in local areas in the Gulf States, *Smithistruma* is by a wide margin the dominant genus in the United States.

Preliminary work by L. G. and R. G. Wesson (1936, 1939) and Brown (1950) on several species of *Smithistruma* and by Wilson (1950) on *Strumigenys louisianae* seemed to indicate that the diets of these two genera are restricted mostly to entomobryoid Collembola, a specialization certainly as aberrant as the structural modifications which characterize these ants. Brown (*in litt*) has recently determined that the Australian genera *Orectognathus*, *Alistruma*, *Clarkistruma*, and *Epopostruma* possess similar food preferences; this is especially significant in view of the fact that the first genus is one of the most primitive in the tribe.

Because it was Dr. Brown's original plan to correlate the evolution of food habits with dacetine phylogeny, the present study of North

[1]See also Brown's recent revision of the world *Smithistruma* (Amer. Midl. Nat., 50: 1–137, 1953). This contains a recapitulation of dacetine classification along with an abundance of field data on the North American species.

American forms was initiated to complement his work in Australia, and a great emphasis has been laid on food habits alone. Certain data accumulated on other aspects of ecology have been mostly incidental but are included here, along with what meager conclusions can be drawn from them, because they represent the first information of this sort published on the tribe.

In the present study the most efficient observation nest developed for the small North American forms was a little plaster of Paris Janet nest four inches long, three inches wide, and three-fourths of an inch deep. This was cast in the bottom of a square ice-box dish, and the top surface was scraped to extreme smoothness with a glass plate as soon as the plaster began to harden. The food chamber was about half an inch deep and occupied half the space of the nest. Brood chambers and interconnecting galleries were excavated in the plaster with a fine knife and made to simulate the natural nests as much as possible. The ants were transferred to this type of nest in the following manner: the original nest was taken entire from the field to the laboratory and carefully dissected; the adults and brood were removed individually with forceps or aspirator to another container and dumped together into the food chamber. The plaster nest was then covered with a single plate of glass and placed on some moistened strips of cloth. The Forel Arena technique was found to be impractical in transferring such small, delicate ants, since these are poorly organized and very sensitive to the slightest dessication. Also, if portions of the original nest were placed in the food chambers to facilitate rapid transfer, the ants tended to group permanently around and under these instead of moving into the brood chambers.

FOOD HABITS[2]

Food preferences were determined primarily by introducing as wide a variety of substances as possible into the food chambers and observing the reactions of the foraging workers as they encountered them. It was quickly established that the dacetines are exclusively predacious, so that after a short time the experiments narrowed down to the introduction of small organisms only. Those organisms captured by the ants, carried to the brood chambers, and presented to the larvae were classified as "accepted"; those ignored by the ants despite frequent contacts over a reasonable length of time were classified as "rejected." Both "accepted" and "rejected" organisms were retrieved and preserved for later identification. In the case of prey which had been taken to the brood chambers and covered with larvae, this removal often proved to be a delicate operation. Best results were obtained by brushing the larvae aside with a dry needle and picking out the prey with a needle made slightly adhesive with alcohol.

In must be emphasized that since adults were rarely observed in the act of feeding, the food preferences to be discussed apply essentially to the larvae. There is, however, considerable evidence that the adults feed on the same captured prey as the larvae, only much more sparingly.

[2]Appreciation is expressed to Miss Grace Glance, Collembola specialist of the United States National Museum, for the determination of the Collembola collected in connection with this study.

Strumigenys louisianae Roger

A total of seven colonies of this species from several localities in southern and central Alabama were studied over a period of a little less than a year. As noted in my preliminary paper (1950), the principal food appears to be certain groups of Collembola, although a few other arthropods are taken occasionally, especially if they are dead or injured. The original list of accepted and rejected organisms has been incorporated into the much more extensive one given below.

ACCEPTED ORGANISMS

Collembola
- Entomobryidae: *Entomobrya*, *Lepidocyrtus*, *Orchesella*, *Tomocerus*, *Pseudosinella*.
- Isotomidae: *Isotoma*.
- Sminthuridae: *Ptenothrix*.

Entotrophi
- Japygidae: *Japyx*.

Dictyoptera
- Termitidae: *Reticulitermes*.

Psocoptera
- Psocidae.

Hymenoptera
- Formicidae: *Solenopsis* and *Monomorium* larvae.

Diptera
- Psychodidae, Phyllomyzidae.

Symphyla
- Scutigerellidae: *Scutigerella*.

Acarina—unidentified.

REJECTED ORGANISMS

Collembola
- Poduridae: *Neanura*, *Hypogastrura*.
- Onychiuridae: *Onychiurus*.

A wide variety of other groups, including most of the orders of insects, numerous mites, annelids, isopods, nematodes, spiders, pseudoscorpions, millipedes, and centipedes.

By far the most preferred prey of this species are entomobryoid and symphypleonan Collembola, and these were used to maintain the colonies in the present study. Other arthropods were treated in a somewhat desultory fashion by the ants. When a half dozen or so termites were placed in the food chamber of a nest, they were attacked at once, and although one or two usually succeeded in escaping and hiding under debris, the majority were killed within several hours. Some of the corpses were carried to the brood chambers and consumed, while others were left undisturbed in the food chamber. Psocids and small flies were usually either ignored or half-heartedly attacked by the ants, and those carried to the brood chambers were then only occasionally partly consumed. *Japyx* were vigorously attacked by the ants, which appeared to have an especial antipathy toward these insects, and like the termites they rarely survived more than several hours in the food chamber of a sizeable colony. Legs and antennae were often consumed by the adults and larvae, but the bodies were almost never disturbed.

Only several mites were accepted over the entire period of observation. Since the debris in the food chambers almost always swarmed with a substantial number of species in several families, the possibility must be considered that the *Strumigenys* regularly accept certain forms but reject the majority. There is some evidence that mites are normally accepted in nature (see below). Symphyla were consistently accepted and eaten, to the extent that they seemed to be preferred almost as much as Collembola. Small ant larvae were also readily accepted, possibly suggesting that the *Strumigenys* may on occasion behave as thief ants, although no evidence of this was seen in the field.

A spot check of the food-chamber experiments was attempted by placing a Janet nest containing a colony of *Strumigenys* in a terrarium partly filled with fresh humus and leaf litter, which were taken from several areas and replaced periodically. Occasionally bits of wood containing termites were also added. The ants were allowed access to this material through galleries leading to the outside of the nest. Their prey, checked daily over a two-week period, consisted at least of eleven entomobryids, seven isotomids, four mites, and one symphylan. Except for the unexpected large proportion of mites, this sample is consonant with the prey specificity exhibited by colonies confined to the artificial nests. Attempts were made to established two colonies in Janet nests in the field at the original nesting sites, but in both cases they quickly migrated out and could not be found in the immediate vicinity.

The *Strumigenys* are bolder and more direct in their manner of stalking prey than the other dacetines studied. This trait is perhaps a result of their more efficient mandibles, which are extremely long and supplied with prominent apical teeth. They can be opened to almost a 180° angle and operate very much as miniature animal spring traps. When approaching a collembolan, the worker *Strumigenys* moves slowly and cautiously spreading its mandibles to the maximum angle and exposing two long hairs which arise from the paired labral lobes. These hairs extend far forward of the ant's head and apparently serve as tactile range finders for the mandibles. When they first touch the prey, its body is well within reach of the apical teeth. A sudden and convulsive snap of the mandibles literally impales it on the teeth, and drops of haemolymph often well out of the punctures. If the collembolan is small or average in size, the ant lifts it into the air and curls its gaster forward in an attempt to sting, a surprisingly awkward motion in this species and the other dacetines studied, for in many catches observed it did not appear that the sting entered the body of the prey at all. Nevertheless, all but the largest Collembola are quickly immobilized by this action, and struggling is feeble and short-lived. Apparently the prey are only paralyzed and not killed outright, since most can be prodded into feebly moving even after they have been carried into the brood chamber.

A great deal of individual deviation from the typical hunting behavior occured in the nests under observation. Sometimes workers were much less stealthy in their approach and seemed almost to charge their prey. Frequently they seized Collembola when these insects blundered into them. Dead Collembola were not stalked but were directly picked up after a brief inspection.

Nothing resembling concerted or coordinated stalking on the part of several workers was observed. Hunting in general appeared to be rather haphazard, a condition accentuated by the apparent inability of the ants to recognize the presence of insects more than about a millimeter away. Occasionally workers were seen to stalk and strike Collembola which had already been captured by other workers and were being transported to the brood chambers.

Field observations on the food habits of these tiny and secretive ants are understandably meager. At two localites in Alabama, Gulf State Park and Mobile, stray workers were observed carrying entomobryids. On one occasion, in Mobile, a worker was found carrying a small *Campodea*. As mentioned in my preliminary paper on this species, one nest collected at Tuscaloosa, Ala., contained recognizable insect remains in the galleries; these were identified as belonging to three entomobryoid genera, *Entomobrya*, *Proisotoma*, and *Isotoma*.

Larvae are fed by being placed directly on the prey. As many as ten or more may be piled at first on the same collembolan, and since they are active feeders they may wholly consume a small individual within several hours. The final fragments of the insect are held aloft, ponerine fashion. No case of ingluvial feeding of the larvae by the workers was ever observed, although occasionally workers were seen passing food in this manner.

Trichoscapa membranifera Emery

Two colonies of this species, respectively from Escambia Co. and Tuscaloosa Co., Alabama, were studied during an eight-month period.

ACCEPTED ORGANISMS

Collembola
- Entomobryidae: *Entomobrya*, *Lepidocyrtus*, *Orchesella*, *Tomocerus*, *Pseudosinella*.
- Isotomidae: *Isotoma*, plus one unidentified genus.
- Sminthuridae: *Ptenothrix*.

Entotrophi
- Campodeidae: *Campodea*.

Dictyoptera
- Termitidae: *Reticulitermes*.

Hymenoptera
- Formicidae: *Monomorium* larvae.

Symphyla
- Scutigerellidae: *Scutigerella*.

Acarina—unidentified.

REJECTED ORGANISMS

Collembola
- Poduridae: *Neanura*.
- A diversity of other invertebrates similar to those offered to *Strumigenys louisianae*.

The food preferences of the *Trichoscapa* proved to be about the same as for *Strumigenys*, with a little less latitude in the acceptance of non-collembolan groups. As in *Strumigenys*, mites were taken only on several occasions from a constant supply of diverse forms. Termites were usually ignored, never attacked so persistently as by *Strumigenys*,

and only occasionally were carried into the brood chambers and eaten. *Japyx* were killed but not transported or eaten. *Monomorium* larvae were eaten, but *Solenopsis* larvae were rejected by the *Trichoscapa* brood even though they had been transported by the workers. *Campodea* and *Scutigerella* were both readily accepted.

The *Trichoscapa* are the most active of the dacetines studied and show unexpected pugnacity under certain conditions. *Japyx* and termites were frequently attacked in the artificial nests with a viciousness approaching that of some of the more aggressive larger myrmicines. The little dacetines actually rushed at these insects when they contacted them, seizing hairs or appendages and doubling up in an effort to sting. Although they lacked a weapon of shock such as the mandibles of *Strumigenys*, they were able to panic fairly large individuals and dispose of them as quickly as this other genus. Since insects combatted in this fashion were rarely eaten, it is assumed that such aggressive behavior is used in the defense of the nest.

Stalking of Collembola is in an entirely different mood and is usually executed with far more caution and deliberation than the *Strumigenys* ever show. The *Trichoscapa* worker rarely recognizes an insect until it actually comes in contact with it, but it is very sensitive to nearby movement and probably depends a great deal on this in spotting prey. As soon as the worker becomes aware of the presence of a collembolan, it "freezes" in a lowered, crouching position and holds this stance briefly. If the collembolan is to its back or side, the worker now turns very slowly to face it. Once it is aligned with the collembolan, it begins a forward movement so extraordinarily slow that it can be detected only by persistent and careful observation. Several minutes may pass before the ant finally maneuvers over less than a millimeter's distance to come into a striking position, and it may be remain in this position for as much as a minute or more. During this time the collembolan may move away for one reason or another, in which case the ant rarely attempts to follow but begins to forage anew. Unlike *Strumigenys*, the *Trichoscapa* open their mandibles only to about a 60° angle. Tactile labral hairs are present and eventually come to touch the prey. The mandibular strike is as sudden as that of *Strumigenys*, but since it is usually directed at an appendage, it does not have the same stunning effect on the collembolan. These insects often struggle vigorously to escape, but the ants are very tenacious and retain a fast grip until they are able to sting their prey into immobility.

Unusual behavior in foraging workers was sometimes observed. Occasional bold *Trichoscapa* were seen to approach their prey rapidly and attempt to seize a hair or appendage, and these were frequently successful. Sometimes workers would "freeze" when Collembola were moving rapidly around them and wait without moving, apparently in anticipation of ambushing the animals as these blundered into their mandibles.

Details of larval feeding seem to be similar to those in the case of *Strumigenys*. In addition, the *Trichoscapa* were never observed to participate in any sort of trophallaxis, either between workers or between workers and larvae. As a rule, the *Strumigenys* appeared to be the more efficient in catching Collembola in the artificial nests. Specifically,

when fresh batches of Collembola were placed in the food chambers, colonies of *Strumigenys* were definitely able to accumulate these insects in their brood chambers faster than were *Trichoscapa* colonies of comparable size. However, it is obvious that this difference cannot be taken as a true indication of the relative efficiencies of these two genera under natural conditions, which involve a more scattered food supply and much longer periods of time.

Smithistruma rostrata (Emery)

Seven colonies from several localities in central and northern Alabama were studied over a period of nine months.

ACCEPTED ORGANISMS

Collembola
Entomobryidae: *Entomobrya, Lepidocyrtus, Orchesella, Tomocerus, Pseudosinella, Pseudosira.*
Isotomidae: *Isotoma.*
Sminthuridae: *Sminthurinus, Ptenothrix.*

REJECTED ORGANISMS

Collembola
Poduridae: *Anurida (Brown, 1950), Neanura, Achorutes.*
A variety of other invertebrates similar to those offered *Strumigenys louisianae.*

In marked contrast to the preceding two species, *Smithistruma rostrata* appears to feed strictly on Collembola. Organisms other than the preferred Collembola were completely avoided in the artificial nests and rarely attacked even when they ventured into the brood chambers. Otherwise, this species is essentially similar to *Trichoscapa membranifera* in details of stalking behavior and larval feeding and in the total absence of trophallaxis. Field data on the food habits of this and other species of *Smithistruma* are virtually lacking. On one occasion, near Old Fort, North Carolina, a worker was observed carrying an entomobryid toward its nest nearby.

Smithistruma brevisetosa (M. R. Smith)

One colony of this species from Tuscaloosa, Alabama, was studied over a period of six months.

ACCEPTED ORGANISMS

Collembola
Entomobryidae: *Entomobrya, Orchesella.*
Sminthuridae: *Ptenothrix.*

REJECTED ORGANISMS

Collembola
Poduridae: *Neanura.*
Onychiuridae: *Onychiurus.*
A variety of other invertebrates similar to those offered *Strumigenys louisianae.*

This species appears to be identical in food habits to *Smithistruma rostrata.*

Smithistruma missouriensis (M. R. Smith)

One colony from the Chilhowee Mountains of eastern Tennessee was studied for a period of about a month.

ACCEPTED ORGANISMS

Collembola
Entomobryidae: *Entomobrya, Tomocerus, Pseudosinella.*
Poduridae: *Achorutes.*

REJECTED ORGANISMS

Collembola
Poduridae: *Neanura, Achorutes.*
A small variety of other invertebrates, including isopods, mites, nematodes, and a few small insects.

Only one individual of *Achorutes* was taken by this colony, a remarkable exception to the general rule of Collembola specificity.

Smithistruma talpa (Weber)

One colony from the Chilhowee Mountains of Tennessee was studied for a period of about a month.

ACCEPTED ORGANISMS

Collembola
Entomobryidae: *Entomobrya, Orchesella, Tomocerus, Pseudosinella.*
Isotomidae: *Isotoma.*
Sminthuridae: *Sminthurinus.*
Entotrophi
Japygidae: *Japyx.*
Campodeidae: *Campodea.*
Symphyla
Scutigerellidae: *Scutigerella.*

REJECTED ORGANISMS

Collembola
Poduridae: *Neanura, Achorutes.*
Onychiuridae: *Onychiurus.*
A small variety of other invertebrates similar to those offered the *Smithistruma missouriensis* colony.

Japyx and *Campodea* were captured and carried to the brood chambers but later discarded. *Scutigerella* were readily accepted and eaten. Perhaps in agreement with its broader food perferences, this colony was more active and aggressive than the other *Smithistruma* studied. Its food habits were otherwise similar to those of *S. rostrata.*

Smithistruma clypeata (Roger)

Two colonies from central Alabama were studied over a period of approximately six months.

ACCEPTED ORGANISMS

Collembola
Entomobryidae: *Entomobrya, Lepidocyrtus, Lepidocyrtinus, Orchesella, Tomocerus, Pseudosinella.*
Sminthuridae: *Sminthurinus, Ptenothrix.*
Entotrophi
Japygidae: *Japyx.*
Campodeidae: *Campodea.*

REJECTED ORGANISMS

Collembola
Poduridae: *Neanura.*
A variety of other invertebrates similar to those offered *Strumigenys louisianae.*

One *Campodea* and two small *Japyx* were captured and eaten. These two colonies apparently had food preferences almost as broad as the *Sm. talpa* but were not nearly so active. Food habits were otherwise the same as in *Sm. rostrata*.

Smithistruma dietrichi (M. R. Smith)

One colony from the Chilhowee Mountains of Tennessee was studied for a period of about a month. Unfortunately, it was accidently destroyed before poduroid Collembola could be introduced, so that Collembola specificity was not checked.

ACCEPTED ORGANISMS

Collembola
Entomobryidae: *Entomobrya, Orchesella, Pseudosinella.*
Isotomidae: *Isotoma.*
Sminthuridae: *Sminthurinus.*
Entotrophi
Japygidae: *Japyx.*
Symphyla
Scutigerellidae: *Scutigerella.*

REJECTED ORGANISMS

A small variety of other invertebrates similar to those offered the *Sm. missouriensis* colony.

The several *Japyx* and *Scutigerella* given the colony were totally consumed. Outside of the acceptance of these forms, the food habits of this species appear to be about the same as those of *Sm. rostrata*.

DISCUSSION OF FOOD HABITS

Smithistruma (*Wessonistruma*) *pergandei* (Emery) was studied in some detail by L. G. Wesson (1936), who concluded that it fed exclusively on Collembola. While his experiments present strong evidence that Collembola are the primary food source, they are actually too limited to exclude the possibility that non-collembolan groups are also accepted. In addition, Wesson failed to identify the Collembola accepted, thereby leaving no clue to family specificity. In a later paper (1939), the Wesson brothers listed the following species as Collembola feeders: *Sm. rostrata* (Emery), *Sm. pulchella* (Emery), *Sm. reflexa* (L. G. and R. G. Wesson), and *Sm. talpa* (Weber). Again the prey were not determined and no real evidence was presented that these species are restricted to a collembolan diet. This early work, however, is still of considerable importance beyond its pioneering nature, because it lends to the impression that food habits are uniform throughout the genus.

The Wessons' observation of stalking behavior agree fairly well with my own. A typical catch by *Sm. pergandei* was described as follows: "The moment the worker scents a springtail which is one to four mm. away, depending on its size, she stops suddenly, slowly exploring her antennae in its direction. Having waited for a few minutes, she moves by slow advances to within 1 mm. of it. Then she folds her antennae, lowers her head to the ground and moves imperceptibly in the direction of the springtail until her mandibles almost touch it. Then she waits until the springtail *moves* against her mandibles. When this happens, she strikes, seizing the springtail in her

mandibles, piercing it with her sharp maxillary lobes, then drawing it back and stinging. If, on the other hand, the springtail fails to move, she arouses it by vibrating her antennae around it."

It is doubtful if the ants are able to sense Collembola more than a millimeter or so away, and this species is very exceptional if it waits for its prey to blunder against its mandibles before striking. All of the dacetines observed in the present study followed through the mandibular strike whether their prey moved or not; ambush as described above was unusual. Apparently the Wessons missed the significance of the labral lobes, which they mistook for the maxillae. These evidently function as tactile range finders for the mandibles, are relatively flexible organs, and are probably quite unable to pierce the integument of a collembolan.

Perhaps the most striking feature of the food habits of the dacetines studied is the specificity of preference for certain taxonomic groups within the Collembola. Why the poduroid Collembola are totally ignored while the other groups form the main dietary staple of these ants is not at all clear and remains a very significant problem. It appears to me that the most outstanding difference between the accepted and rejected groups which would be perceptible to one of these ants is in the degree of activity: the poduroids are as a rule extremely sluggish and slow-moving, whereas most other Collembola are wary and capable of rapid movement. It is possible that the poduroids produce a repugnant odor or fluid on the surface of their bodies. This is a fairly common phenomenon in sedentary terrestrial animals which are subject to much predation and tends to replace the ability to take rapid flight. If it does occur in the poduroids, the secretion must be relatively strong, for the ants apparently recognize these insects upon contact and never make an attempt to stalk them.

In some published notes on the behavior of *Strumigenys louisianae*, W. S. Creighton (1937) proposed the interesting hypothesis that this species immobilizes its prey and enemies by spraying them with a toxic fluid. He had come to this conclusion on the basis of two consistent observations made while the *Strumigenys* attacked some small, delicate *Brachymyrmex* which had been placed in their nest: the *Strumigenys* were able to kill these ants rapidly without doing much mechanical injury to their integument, and the *Brachymyrmex* engaged in exaggerated self-cleaning after each attack. W. L. Brown (1950) favored Creighton's idea of a toxic spray and suggested that this might originate from the paired labral lobes. No absolute proof has yet been adduced for or against such a hypothesis, but I am inclined to believe that either it is produced in microscopic amounts or it does not exist at all. Very early in the present study it was noted that workers of *Strumigenys* and *Trichoscapa*, and to a less extent those of *Smithistruma*, tended to be unusually aggressive while in the confines of the brood chambers. When the glass cover was moved over their heads they often attacked it, snapping at it with their mandibles and attempting to sting it. As this occurred I watched for signs of droplets appearing on the glass, but these were never apparent, even at magnifications of 60x. Also, fine bits of cobaltous chloride paper thrust at attacking workers did not pick up visible amounts of moisture. It is very probable that Dr.

Creighton underestimated the ability of these ants to injure and cripple insects with the use of their mandibles alone, for the shocking effect of the mandibular strike appears to be considerable. In my nests smaller Collembola usually yielded at once without a struggle when struck on the body, while larger insects such as *Japyx* were often thrown into a complete and immediate panic, reactions which can hardly be attributed to a tiny amount of fluid. It is curious that Dr. Creighton did not mention whether his *Strumigenys* employed their stings, because this was normal behavior in my colonies and played an important part in defense and the capture of larger prey.

One of the most characteristic features of dacetine ants is the widespread possession of concentrations of well developed and frequently aberrant hairs on the head. These are especially abundant on the clypeus, and the resemblance of many of them to the hyphae and fruiting bodies of fungi has led Brown (1950) to propose that they may serve as tactile or visual lures for the Collembola on which the dacetines feed. This is certainly a logical and tempting hypothesis, but one that would be very difficult to prove or disprove. In my own observations nothing resembling luring was ever found, although it is readily admitted that the conditions under which the Collembola were introduced into the artificial nests and the bright light required to watch them were hardly conducive to normal feeding behavior on the part of the Collembola. On the other hand, it seems very likely that under natural conditions a luring mechanism would add little to the efficiency of the ants in stalking prey, primarily because they seek their prey actively and need only to keep it from bolting before they seize it. Brown evidently conceived of the investiture as a lure while under the erroneous impression, given him by the Wessons' original observations, that some dacetines such as *Smithistruma* rely on ambush to catch Collembola. A more logical function of the investiture would be to deceive the Collembola with its fungus-like appearance as the ant approaches and thus prevent it from becoming frightened and moving away before the ant can spring the mandibular trap. A possible example of such of a function was noted in the case of *Smithistruma dietrichi*, which possesses a sparse cluster of long, filiform hairs around the anterior margin of its clypeus. Workers of this species were observed as they stalked Collembola, palpating them lightly with their antennae and frequently brushing them with their clypeal hairs. The latter contacts were irregular and apparently accidental, and did not seem to be tactile in function. The significant thing is that these contacts did not frighten the Collembola, which were very wary and ordinarily bolted when brushed by mites or other Collembola. Another point in favor of this interpretation is that if the cephalic hairs of dacetines truly mimic parts of fungi, this mimicry probably is tactile and not visual in nature. Collembola are provided with ocelli only, organs generally thought to be incapable of form preception. But even if they were capable of distinguishing the shape of the hairs, they would receive little opportunity to do so, since both Collembola and dacetines are predominantly hypogaeic. Thus the Collembola would have no incentive for going to the dacetines on the basis of the form of the hairs alone and could be deceived only by actually touching the hairs.

Foraging activity under natural conditions is a subject which has received scant attention in the previous literature. Smith (1930), the Wessons', Brown, and Creighton all have agreed that the United States dacetines are cryptobiotic and hypogaeic, rarely if ever appearing in the opening. In the case of *Trichoscapa membranifera* and the species of *Smithistruma* there is little doubt that this is for the most part true. Stray workers of these two genera are found typically in very hidden, protected places, as under the bark of rotting logs and stumps, under stones, and in the lower strata of leaf litter. *Strumigenys* workers, however, are also found frequently in open situations and apparently normally forage there even during the day. They have been taken abundantly in thin leaf litter in a number of localities, sometimes many feet from the parent colony. Others have been found occasionally in such situations as well tended lawns, piles of garbage, and on exposed roots in wooded areas.

LIFE HISTORIES

North American dacetine colonies are uniformly small, the majority containing between 25 and 100 workers and one to several mother queens. The largest colony of *Strumigenys louisianae* I have collected contained 181 workers, 119 larvae, and one queen. The larger of the two *Trichoscapa membranifera* colonies collected in Alabama contained 36 workers, two larvae, and one queen. Smith (1931) has reported a colony of this species from Mississippi with 75 to 100 workers. The largest *Smithistruma* colony I have collected was one of *Sm. pergandei* from western North Carolina; it contained 146 workers, and undetermined number of larvae and pupae, four alate queens, and one dealate queen. It appears that the species of *Smithistruma* tend to have larger colonies in the northern part of their ranges, where Brown (*in litt.*) has found colonies of a hundred or more workers to be very common. The largest of many collected in Alabama by Mr. B. D. Valentine and myself contained only 62 workers (*Sm. clypeata*).

The small colony size appears to be the result of a low rate of oviposition, combined with a further reduction of the total number hatching through consumption of some by the adult ants. The number of eggs present in a colony over a period of time fluctuates around what appears to be a nearly constant mean. This is illustrated by the following daily counts from two *Smithistruma* colonies. *Sm. rostrata:* 1, 1, 2, 6, 7, 7, 7, 5, 6, 7, 7, 2, 1, 7, 3. *Smithistruma brevisetosa:* 10, 7, 4, 8, 5, 3, 5, 6, 6. These counts are approximately representative for colonies of average size of all the species studied.

Examination of a substantial accumulation of records made in several states by B. D. Valentine, A. C. Cole, D. W. Pfitzer and myself has shown that winged forms appear at definite and restricted intervals in the year. They are produced by *Strumigenys louisianae* in the Gulf States predominantly in the last half of June and first half of July. They are produced by all the native *Smithistruma* for which records are available mainly during late August and early September, there being little difference in this respect between the northern and southern segments of the populations. The only winged form of *Trichoscapa membranifera* from the United States with which I am

familiar is a queen mentioned by Smith (1931), who took it as a stray on July 18, in Mississippi.

New colonies are apparently formed at least partly through swarming in the typical formicid manner. Male *Strumigenys* reared in the laboratory showed swarming behavior on one occasion after the nest had been freshly mositened and warmed somewhat. They ran rapidly back and forth in the lighted food chamber and vigorously attempted to take flight. In the field, stray dealate queens of the following species have been taken; *Strumigenys louisianae*, *Trichoscapa membranifera* (Smith, 1931), *Smithistruma* (*Wessonistruma*) *angulata*, *Sm.* (*W.*) *pergandei*, *Sm.* (*Smithistruma*) *bimarginata* (Wessons, 1939), *Sm.* (*Sm.*) *dietrichi*, *Sm.* (*Sm.*) *margaritae*, *Sm.* (*Sm.*) *pulchella*. Some evidence exists that the young queens forage and capture Collembola for their first brood. The Wessons observed dealate queens of *Smithistruma talpa* (= *medialis*) hunting in a fashion similar to that of the workers. In my own nests several *Smithistruma rostrata* mother queens deprived of workers foraged some within the limits of the brood chambers and succeeded in capturing

TABLE I

Duration of Life Stages of Three Dacetine Genera

	Duration in Days		
	Egg	Larva	Pupa
Strumigenys louisianae	12	29	12
Trichoscapa membranifera	13	19	19
Smithistruma rostrata	9	31	19
Smithistruma clypeata	14	25	14

a few emtomobryids which they fed to their brood. A dealate queen of *Strumigenys louisianae* taken as a stray in the field and maintained for a few weeks in an artificial nest foraged continually in the food chamber and was observed on two occasions carrying entomobryids. She was actually watched in the process of catching one of these; her stalking movements resembled in every way those described previously for the workers of this species. If it is true that dacetine queens found colonies in a partially claustral manner and depend on hunting to nourish their first brood, this represents another remarkable trait for the tribe and would be the only instance with which I am familar of this type of behavior in the Myrmicinae.

An attempt was made to determine the approximate duration of the different life stages of the three genera considered in this study. For this purpose nests were maintained at a nearly constant temperature of 27° C, which was ascertained by trial and error to be reasonably close to the optimal range of the species reared. The data obtained for workers are summarized in the accompanying table. In addition, queen pupae of *Strumigenys louisianae* took 12 days and male pupae 13 days to develop. In reality, these data are of such a limited scope and the conditions of constant temperature under which they were obtained so unnatural that they cannot be considered as showing significant differences between species, but they may be taken as approximations for the three genera as a whole.

NESTING HABITS

Most of the dacetines known from the eastern United States are very highly restricted in habitat. This is evidently due more to the selection by the ants of particular micro-ecological conditions than to the effects of any gross factors of the physical environment. Specifically these conditions appear to be a high degree of humidity, which must be maintained nearly constant, plus a favorable nesting medium of readily workable yet firm material, such as humus and punky wood. Thus the ants are not restricted to any particular forest cover, but they do tend to be more abundant in those plant associations which provide the best types of rotting logs and stumps, the right degree of shade to allow moisture retention in those logs and stumps, and possibly also the most favorable topsoil and leaf litter. In general, the dacetines are most common in fairly dense mixed mesophytic woods, where they nest in moist, "Passalus-stage" rotten wood, in rotting twigs and small branches on the ground, and to a lesser extent under rocks sunk shallowly into the soil. Where pine logs and stumps are common, these are preferred. In the Southeast at least, the very best place to look for these ants is the high ground of swamps with mixed forest cover. Here they may compose in some spots upwards of five percent of the total ant population. Frequently, however, the habitats which appear to be most favorable for dacetines do not always offer a rich Collembola supply and these arthopods are often the most abundant in places where few or no dacetines occur.

As might be expected from its tramp distribution, *Trichoscapa membranifera* appears to be the most adaptable dacetine in the eastern United States. Colonies have been collected from all the situations typical for the tribe, as well as from the bulb of a gladiolus (Smith, 1931) and under bits of slate in a cultivated field. This species also probably has the least strict moisture requirements, venturing often into relatively dry, open soil. *Strumigenys louisianae* also occurs in all the typical dacetine habitats, and colonies have also been found in such situations as debris in a knothole of a living tree (Pfitzer, personal communication), in leaf litter at the base of a tree, and in soil covered only by moss. *Smithistruma rostrata* was the most adaptable species studied in its genus. Colonies were found in rotting logs and stumps in twigs and small branches buried in leaf litter, in old, crumbling sweetgum burs, and even in exposed leaf mold. There is considerable evidence that the species of *Smithistruma* tend to specialize further in selection of nesting sites, each one being restricted primarily either to rotten wood or to the bottom of surface rocks. This has been considered at length by W. L. Brown in his revision of the genus (1953, ref. in footnote 1) and will not be covered here.

The dacetines construct their own nests, occasionally utilizing preformed cavities as starting points. They may be one to several brood chambers, all of which are kept immaculately clean. They are flat and oval in shape and rarely exceed five centimeters in greatest diameter. Galleries are nearly always very short and indistinct. In my artificial nests, excavation was most frequently conducted by the *Strumigenys*, which often burrowed galleries straight through the soft plaster of Paris, so that the walls had to be continually patched to prevent the ants from escaping. The *Trichoscapa* and *Smithistruma*

limited themselves to building walls and enclosures with the debris available in the nests. One small *Smithistruma reflexa* colony built within a brood chamber a small igloo-shaped structure which completely covered the queen and brood.

MYRMECOPHILES

North American dacetines are almost totally free of myrmecophiles, a condition probably due to the small size of the colonies and the virtual absence of trophallaxis. Several truly myrmecophilous mites, identified by Dr. E. W. Baker as nymphs of the family Laelaptidae, were found in a colony of *Strumigenys louisianae* taken near Georgiana, Alabama, and were maintained in an artificial nest with the ants for a period of two months. During this interval they were extremely sedentary, spending most of the time riding on the bodies of their hosts. One individual remained on the ventral surface of the postpetiole of the queen and was never seen to move from this position. The ants appeared to be completely indifferent to the mites' presence and in return received no visible harm from them. The food of the mites could not be positively determined, but on several occasions individuals were observed moving their mouthparts over the surface of a packet of eggs. It is possible that they were feeding on the collaterial products of the queen.

DISCUSSION

The dacetines are in many ways among the most aberrant and specialized of ants, for nearly all of the details of their biology reflect their peculiar predacious habits. Colonies are exceptionally small, the larvae feed directly on the prey brought in by the workers, there is practically no trophallaxis, mymecophiles are very scarce, and the adult ants themselves have undergone such extreme modifications in morphology and behavior that they function as little more than living Collembola traps. In many aspects of their biology the dacetines resemble the Ponerinae, although they are undoubtedly far more specialized.

One of the most interesting features of the tribe which has not yet been considered is the ability of moderately large numbers of species to occupy the same immediate habitats, even though they are ecologically very uniform. In North America at least, the Formicidae as a whole seem to comply with the well demonstrated principle that ecologically identical species cannot occupy the same niche indefinitely; that is, within a given localized area one or a limited number of species will come to predominate because they possess a competitive superiority in the particular ecological conditions of the area. Thus it is evident that the number of species of a genus which can occupy a given habitat is a function of the degree to which its species compete there. The degree of competition would in turn be dependent on at least two characteristics of the species. First, the greater their diversity in such features as nesting site preferences, food habits, size, etc., the less would be the competition. Second, the greater the density of the total population of the genus, the greater would be the competition. Genera such as *Camponotus* and *Pheidole* are represented in many habitats by large numbers of species perhaps because these tend to be ecologically

diverse; in *Pheidole* there is also considerable variation in size. Genera such as *Myrmica* and *Formica* contain numerous species, but in any given restricted area it is difficult to find more than several which are truly abundant. This may well be due to their tendency toward ecological uniformity. As populations become excessively dense, as has happened occasionally following the introduction into new areas of such forms as *Pheidole megacephala*, *Iridomyrmex humilis*, and *Solenopsis saevissima*, the number of competing species becomes drastically reduced.

The unusual sympatry of the dacetines may be partly a result of their low population densities. Colonies of these ants are probably as abundant as those of many other common tribes, but the total number of workers is significantly lower because of the small average colony size. This allows a good representation of species within a single habitat without too great a population pressure resulting.

SUMMARY

1. A study was made of the ecology of eight North American species of dacetine ants, including *Strumigenys louisianae*, *Trichoscapa membranifera*, and six native *Smithistruma*. Food habits were emphasized.

2. The main dietary staples of these ants are entomobryoid and symphypleonan Collembola. Poduroid Collembola are consistently rejected. *Strumigenys* and *Trichoscapa* show the greatest latitude in food preferences, accepting occasionally Symphyla, Thysanura, termites, and mites. *Smithistruma clypeata*, *Sm. dietrichi*, and *Sm. talpa* may also take Symphyla and Thysanura, but less readily.

3. The hunting behavior of these dacetines is described in detail. All rely on stealth and actively stalk their prey, using their paired labral lobes as tactile organs, and seizing the prey with a convulsive snap of their mandibles.

4. No evidence of a toxic spray as suggested by Creighton (1937) was found. The bizarre cephalic hairs may mimic parts of fungi, as Brown (1950) has speculated, but they cannot serve as visual lures and probably do not serve as lures of any kind, but rather may be used to deceive Collembola being stalked by the ants.

5. Notes on life histories, nesting habits, and myrmecophiles are given. There is some evidence that colonies are founded in a partially claustral manner and that the queens hunt Collembola for their first brood.

6. The high degree of sympatry of ecologically uniform species in the Dacetini is emphasized. It is suggested that this may be partly a result of unusually low population densities.

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VIRUS AND RICKETTSIAL CLASSIFICATION AND NOMENCLATURE, by ROY WALDO MINER (Editor). Ann. New York Acad. Sci., 56 (3): 381–622. 1953. Price, $4.00.

In these symposia, the youthful but very vigorous science of virology has received important additions to its more comprehensive literature. Forty-six men, all outstanding in their respective fields and representing all continents except Asia, have participated as major contributors (nineteen to the first symposium, twenty-nine to the second, with two taking part in both). The discussions are, in all, much more thought-provoking than conclusive; the open admission of our ignorance as to what viruses are, what their origin is and whether they are monophyletic or polyphyletic, how they multiply and whether all multiply in the same fashion, pervades the two volumes. Yet the discussions are meaty, and a large amount of information is marshalled in attempting to prove the contentions of the individual contributors.

The symposium on virus multiplication includes, after each paper, the discussion which followed, though in an edited form designed to present the scientific, rather than the personal, aspects. Naturally, there is unevenness in the treatment, and the same will apply to the requisite level of understanding of the reader, some papers, such as those dealing with protein synthesis and virus multiplication considered as a form of such, having a strong biochemical or physiological basis. On the other hand, André Lwoff's lucid discussion of phage reproduction can readily be understood by the biologist untrained in physiology. A short contribution by G. H. Bergold deals with the multiplication of insect viruses, and some insect-transmitted viruses are considered in other parts of the volume.

Though a majority of the contributors to the second symposium accept the Linnaean system of binomial nomenclature, at least with restrictions, many disagree with this procedure or refuse to adopt it at the present time. P. Limasset clearly discusses the advantages of the Linnaean system and states and answers five outstanding arguments against its adoption. These are, briefly stated: (1) it is not certain that viruses are organisms; (2) the concept of species, and more particularly of the higher categories, is difficult to establish; (3) the properties of viruses are not well enough known; (4) the form of some viruses may be artifacts; and (5), with lack of criteria, it will be difficult to imagine starting binomials. The first argument is the crux of the whole matter; if viruses are organisms, the Linnaean system must be used. The other difficulties are shared, in a less aggravated form, with other fields of biological sciences, and the entomologist can readily think of good examples.

The second symposium includes sections on the taxonomy of insect viruses, by G. H. Bergold and Edward A. Steinhaus; on arthropod-borne encephalitis viruses, by W. McD. Hammon, Pierre Lépine, and Albert B. Sabin, and on the rickettsiae, by J. D. W. A. Coles and Cornelius B. Philip.—M. T. J.

THE MOUTHPARTS OF THE MALE MOSQUITO ANOPHELES QUADRIMACULATUS SAY

(Diptera: Culicidae)[1]

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This study was initiated because of the unsatisfactory and somewhat contradictory statements in the literature in regard to the mouthparts and food habits of male mosquitoes. Although in the beginning the aim was to investigate the food habits of male mosquitoes, it was found necessary to place first emphasis on the anatomy of the mouthparts and their relationship to one another.

There are comparatively few published references to the food habits, anatomy and functioning of the mouthparts of male mosquitoes; many of the early statements apparently were simple assumptions based on little or no evidence. Mitchell (1907) quoted many old ideas and offered a few recorded cases of male mosquitoes actually biting man; however, she also stated that males cannot bite because their mouthparts are not developed to pierce animal tissues. Bates (1949) stated that male mosquitoes captured biting man have been found to be gynandromorphs. Snodgrass (1944) wrote that male mosquitoes may feed on plants by puncturing the plant tissue and sucking the juice; yet, observations of the actual feeding process were not cited by him.

Knab (1907) observed male *Aedes spencerii* in the act of feeding on the nectar of willow flowers and described the actions of the mosquitoes during the feeding process. He had observed mosquitoes visiting a great variety of flowers and theorized that species of mosquitoes are not limited to particular species of flowering plants. He also stated that there are no structural modifications which would make certain species better adapted to particular plants, but cited no evidence for this assumption. He concluded that the food choice of male mosquitoes is a question of the accessibility of plant juices coupled with the season the mosquito species appears.

Mitchell (1907) reported that male mosquitoes were observed ingesting human perspiration, and that they were known to visit fecal material. Bates (1949) reported the collection of males of several species, including large numbers of *Psorophora cingulata*, from stable traps in Colombia. He suggested that all species were attracted to the traps by the odor of sweat or feces, and that the relative abundance of the *P. cingulata* males probably reflects some distinctive food habit.

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[1]Taken from a thesis submitted in May, 1952, to the Graduate School of Tulane University in partial fulfillment of the requirements for the degree of Master of Science.

[2]The author is very grateful to Dr. George Henry Penn for his guidance, assistance and encouragement in this investigation, and also to Dr. Albert Miller, who furnished all the specimens used.

Recently West and Jenkins (1951) offered indisputable evidence that male *Aedes communis* will visit plants to ingest their juices and nectars. In a simple experiment they recorded the presence of radiophosphorus (P^{32}) in the mosquitoes after they had apparently fed on treated flowering plants. It has become standard practice in the maintenance of laboratory colonies of mosquitoes to provide either sugar solution or cut-up fruit of any variety as food for the males.

In the early study of the anatomy of mosquito mouthparts the presence of maxillae in male mosquitoes was first recorded by Thompson (1906) who believed, however, that mandibles were completely lacking. Howard, Dyar and Knab (1912) offered further proof of the presence of maxillae in the male with illustrations of cross sections taken at several levels of the proboscis of *Culex pipiens*. They described the maxillae as thin lamellae composed of transparent chitin, one-fifth as long as the labium. No mandibles were found, but they did find that the hypopharynx was coalesced with the anterior wall of the labium. Folsom (1922), evidently generalizing on the data of Howard, Dyar and Knab, stated that the mandibles of male mosquitoes were aborted.

It was not until Marshall and Staley (1935) did their comprehensive study on generic and subgeneric differences in the mouthparts of male mosquitoes that the presence of mandibles in some species was actually established. They listed the different genera and subgenera in which mandibles may be expected. There have been no recent contributions to the knowledge of the mouthparts of male mosquitoes since that of Marshall and Staley.

METHODS

Source of Material

The mosquitoes used in this study were obtained from the insectary maintained by the Department of Tropical Medicine and Public Health of the Tulane Medical School in New Orleans. They were reared from eggs laid in a long established laboratory colony. All specimens were taken alive from the breeding cages, anesthetized with chloroform or cigarette smoke, and then placed immediately in 70% alcohol.

Dissecting Technique

The most satisfactory tool used in dissecting out the mouthparts was found to be a minute nadel mounted on a toothpick; anything larger proved to be clumsy; anything finer would probably have been an advantage. The makeshift dissecting needles were sharpened on a sharpening stone to a very fine point. The stone was kept handy in the event the point should become dull, as was often the case.

To begin the dissection, the mosquito was first beheaded and the head placed on a slide with a drop of water and a drop of glycerine (to prevent rapid evaporation). The antennae were then removed. By placing a needle under the clypeus and lifting gently the labrum could easily be drawn out of the proboscis. Since the hypopharynx is fused to the labium, it proved the most difficult of the mouthparts

to dissect out. The procedure followed was to lift up the labrum so that the hypopharynx was visible, then, after cutting through the inner wall of the labium, the tip of a dissecting needle was placed beneath the hypopharynx at its proximal end and run distally throughout the length of the labium. Care was taken while doing this not to break the hypopharynx at any point as it was found to be an extremely tedious task to separate the remaining portion from the labium. Also, it was found inadvisable to begin dissection at any point other than at the proximal end.

By probing between the bases of the maxillary palpi and the clypeus the bases of the mandibles and maxillae, which are in very close approximation, could be exposed and lifted out. The mandibles and maxillae were then easily separated by gently rolling them on the slide with the tip of the dissecting needle.

Sectioning and Staining

Robinson (1939) suggests the double-embedding (cellodin) method for use in sectioning mosquito mouthparts, but an easier method was employed in this study with satisfactory results. The method used is outlined in the following paragraphs.

Each specimen was taken from 70% alcohol and its antennae removed. The mosquito was then cut through the middle of the thorax to allow an area for handling with forceps, without doing injury to the head and mouthparts, and yet eliminating non-essential parts that might hinder proper orientation when placed in paraffin.

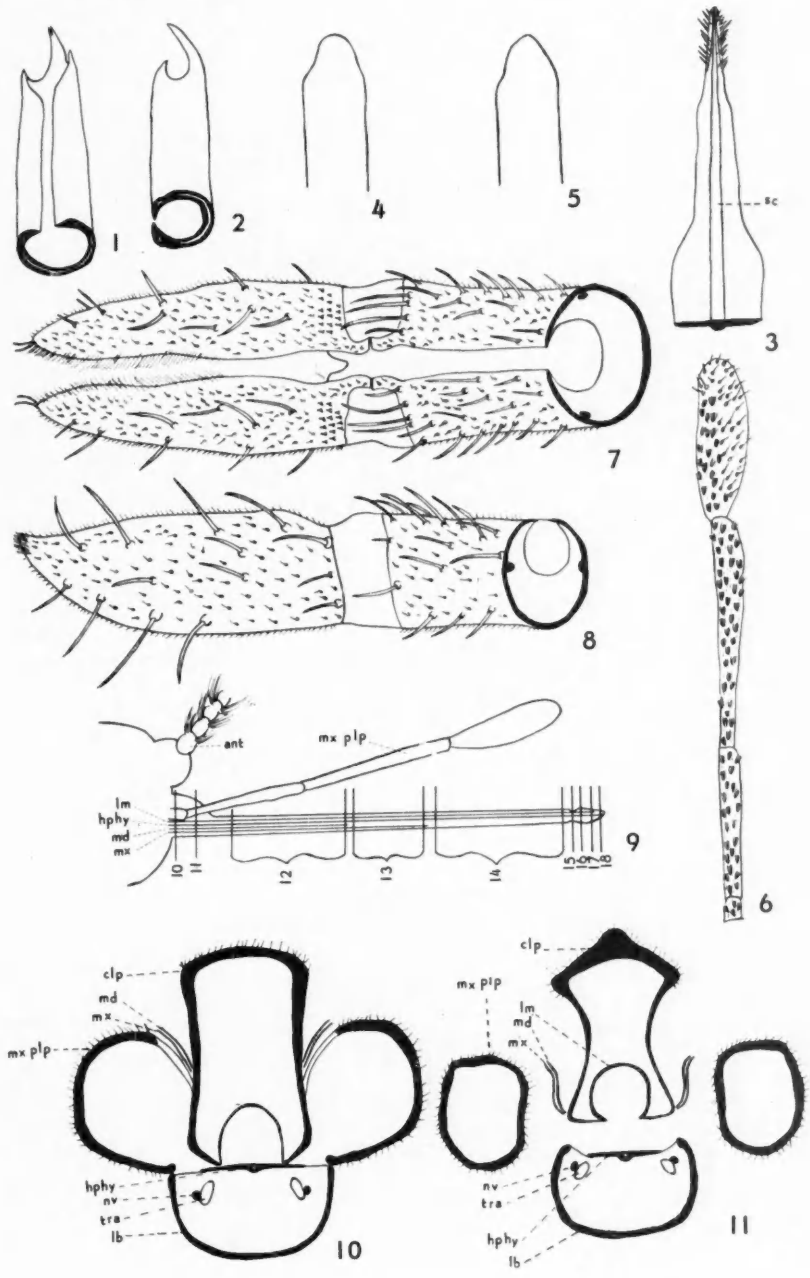
In order to soften the sclerotized tissue the specimen was placed in a 20% solution of acetic acid for a period of two hours. The specimen was then dehydrated by passing it through a series of alcohols, 75%, 85% and 95% to absolute alcohol, remaining approximately 3 to 5 minutes in each solution. Then the specimen was placed in a 50–50 solution of absolute alcohol-xylol for 5 minutes, in xylol for 5 minutes and in a 50–50 mixture of xylol-paraffin for an equal amount of time. The specimen was then mounted in pure paraffin. Sectioning was done at 10 microns and the sections stained in acid fuchsin.

EXPLANATION OF PLATE I

FIGS. 1–5. Tips of mouthparts of male *Anopheles quadrimaculatus*: 1, labrum, posterolateral view; 2, labrum, side view; 3, hypopharynx; 4, mandible, 5, maxilla. FIG. 6. Maxillary palpus. FIG. 7. Tip of labium, anterior view. FIG 8. Tip of labium, side view. FIG. 9. Diagrammatic lateral view of proboscis and maxillary palpus to show respective levels of transverse sections illustrated in figures 10–18. FIG. 10. Section at base of proboscis through clypeus and labium. FIG. 11. Section through distal end of clypeus and proboscis.

KEY TO ABBREVIATIONS USED IN FIGURES

ant	antenna	mcl	muscle
clp	clypeus	md	mandible
hphy	hypopharynx	mx	maxilla
lb	labium	mx plp	maxillary palpus
lbl	labellum	nv	nerve
lig	ligula	sc	salivary canal
lm	labrum	tra	trachea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THE MOUTHPARTS

Gross Structure

Labrum (figs. 1–2).—The most anterior of the mouthparts is the labrum. It is a double walled cylinder open posteriorly throughout its length, and tapering somewhat at its distal end to four sharp, curved points. Except for its proximal fourth the labrum is enclosed by the labium.

The distal tip of the labrum is made up essentially of four fine points: two rather closely adjacent median points at the very tip, which curve posteriorly and a pair of points posterolateral to the tip curving anteriorly. Viewed from the side the distal end of the labrum is roundly grooved.

The labrum appears rather strong, that is, strong enough to be functional in the transport of liquid food. The forked tip, although seeming quite sharp, is soft and probably could not be used for piercing solid structures of either plants or animals.

Hypopharynx (fig. 3).—Directly posterior to the labrum is the hypopharynx which is thin and lamelliform and extends nearly to the very tip of the labium. It is entirely enclosed in the labium, to which it is apparently fused by its lateral edges. Only the distal tip appears to be free.

The hypopharynx is exceedingly fragile and flexible. The salivary duct forms the midrib of the leaf-like organ and it runs throughout the entire length. At its distal end the lamella and the midrib taper to a point which is clothed with a brush-like assemblage of rather stout hairs.

Mandibles (fig. 4).—The mandibles lie parallel to and anteriomesad to the maxillae. They are of very delicate construction. There is no gross difference that can be established between the mandibles and maxillae except for the fact that the mandibles are approximately two-thirds the length of the maxillae. The tips of the mandibles are rather blunt.

Maxillae (fig. 5).—The maxillae are relatively long, flat organs of very delicate construction found posterolaterad to the mandibles with which they are in close approximation. They can be easily separated by careful manipulation as suggested in the section on dissection technique. There is no sharp point on the maxillae of the males like that found on the maxillae of the female mosquitoes. On the basis of their tips alone the mandibles and maxillae of the male

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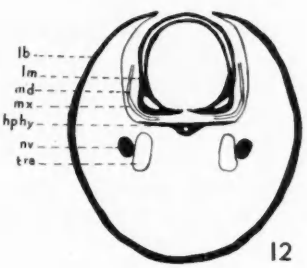
EXPLANATION OF PLATE II

FIG. 12. Section through basal third of proboscis illustrating general relationship of all the mouthparts. FIG. 13. Section through center of proboscis beyond extremity of mandibles. FIG. 14. Section through distal third of proboscis beyond extremity of maxillae. FIG. 15. Section through the most proximal ends of the labella. FIG. 16. Section through middle of the labella. FIG. 17. Section through labella near distal end of labrum. FIG. 18. Section near distal tips of labella. FIG. 19. Cross section through proboscis of female mosquito (redrawn from Robinson (1939) after Vogel (1920)).

(See page 498 for explanation of abbreviations).



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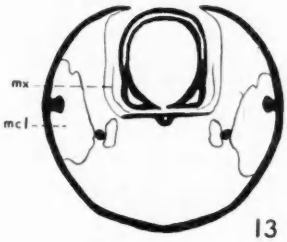

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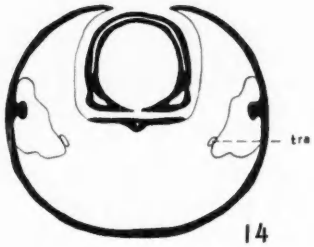

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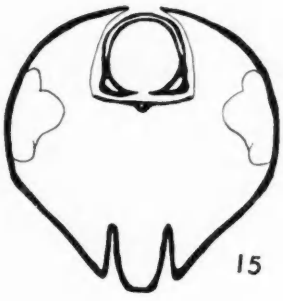

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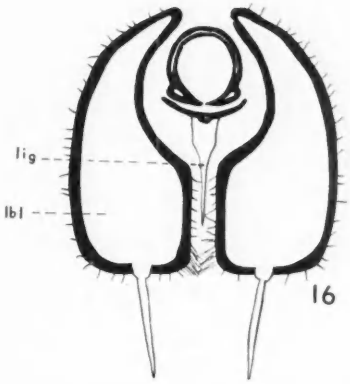

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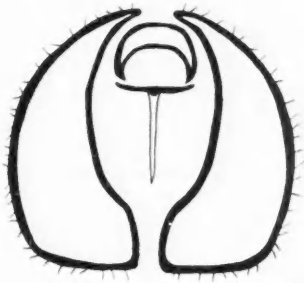

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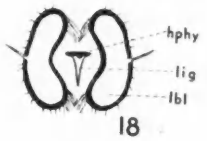

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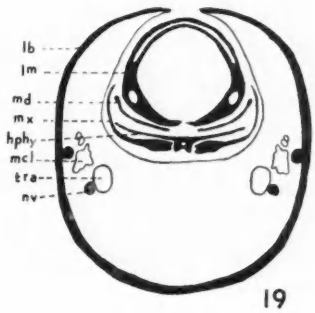

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are usually indistinguishable from one another, although the maxillae tend to be slightly more attenuated in some instances.

The length of the maxillary palpi (fig. 6) varies from slightly less to slightly greater than the proboscis. The palpi are four-segmented, club-shaped organs with the last (distal) segment being the largest.

Labium (figs. 7 and 8).—The labium is an elongate cylinder approximately four times the length of the head. It tapers slightly distally and is open anteriorly throughout its length. The labium is double-walled and very pilose, with numerous, scattered bristles on the outer wall. It houses all the mouthparts, except the maxillary palpi.

At its distal end the labium forms two movable labella which enclose the terminal ligula and the distal portions of the labrum and hypopharynx.

The labium is very strong and flexible, and resembles the labium of the female.

Comparative Lengths of the Mouthparts

The general procedure of Marshall and Staley (1935) was used for measuring mouthparts. The length of the proboscis (labium) was established as 100 units and the remaining mouthparts were taken as a percentage of this figure. An ocular micrometer disc was used in a compound microscope; measurements were taken under low power (10× ocular with the basal element only of the 10× objective; corrected focal length 32 mm.; approximate magnification 45×).

VARIATION IN THE LENGTH OF THE MOUTHPARTS OF MALE *Anopheles quadrimaculatus**

Mouthpart	Number of Individuals Measured	Range	Mode	Mean
Mandible	23	36– 46	41	40
Maxilla	21	50– 62	60	58
Labium	24	83– 99	97	96
Palpi	26	86–102	98	97

*Labium = 100.
Hypopharynx = 99.9.

The number of specimens of each mouthpart measured is given in the following table. The "range" represents the maximum and minimum figures for each mouthpart. To make the study more nearly complete the mean (average) and the mode are also listed. The hypopharynx is not included in the table since in every case the length was found to be almost equal to that of the labium, *i.e.*, about 99.9%.

There is an interesting correlation between the figures listed in the table below and those given by Marshall and Staley for the subgenus *Anopheles*. They used the combined data from three species of *Anopheles: maculipennis, claviger* and *plumbeus*. They found the size range of the mandibles to be 38–46, mean = 42, and the size range

of the maxillae to be 44–68, mean = 56. Since, however, Marshall and Staley failed to give further data, such as the number of specimens used and the method used in determining the mean (not average, they say), their figures cannot be further compared with those of this study. Nevertheless, as stated before, the figures do show an interesting similarity.

It is also significant to note the wide range of length exhibited by the mouthparts as a result of individual variation. All mosquitoes used were taken from one breeding cage of a long established laboratory colony, thus eliminating the possibility of geographic variation by using a truly panmictic population. The figures obtained by Marshall and Staley could not be used to measure individual variation since they combined results from three different species.

Relationships as Seen in Cross-Sections

Figure 9 represents a diagrammatic lateral view of the proboscis and maxillary palpus and shows the level of the transverse sections figured and discussed below.

The mandibles and maxillae originate between the maxillary palpi and the clypeus outside of the labium (fig. 10). They are thicker near the point of origin than they are as they taper distally (figs. 10, 11, 12). It should be noted that where the mandibles and maxillae originate the maxillary palpi are attached to the base of the proboscis and to the clypeus (fig. 10), but in a short distance become separated (fig. 11).

The mandibles and maxillae lie in close approximation throughout their lengths and in the proboscis they take their position posterolaterad of the labrum as they do in the female (figs. 12, 19). A close comparison of figure 12 with the section of the proboscis of the female mosquito (fig. 19), seems to indicate that the mesal portion of the male maxilla has been lost or fused to the hypopharynx, and all that remains is the part corresponding to the lateral, flattened portion of the female maxilla.

The mandibles do not extend as far distally as the maxillae being only two-thirds as long (fig. 13). Figure 14 is from a section below the distal tip of the maxillae.

The labrum while approximately the same diameter throughout most of its length (figs. 12–15), tapers a little distally (figs. 16, 17).

Except for the distal end, the entire length of the hypopharynx is fused to the inner wall of the double-walled labium (figs. 10–15). This helps to explain the difficulty encountered in removing the hypopharynx from the proboscis. The hypopharynx, like the labrum, tapers distally (figs. 17, 18).

When viewed in cross-section the labium appears as an open circle (figs 12–14). However, where the labium begins to differentiate into the labella it takes a different form (figs. 15–18). The ligula is not well developed in the male; it is flattened laterally and fused anteriorly to the hypopharynx (figs. 16–18).

DISCUSSION

The assumption made by previous authors that the male mosquito lives mainly on plant juices, is, in effect, validated by the findings

of the present study. The statement made by Snodgrass (1944) that the male mouthparts can penetrate plant tissue lacks substantiating evidence and is not in accord with the findings of this study.

However, specific records of anopheline mosquitoes, male or female, visiting flowers are lacking in the literature. In fact, Philip (1943), who studied the possibility of using flowers as attractants for mosquitoes, noted the conspicuous absence of anophelines at this source although species in other genera were collected.

The labrum looks strong enough for use in the transport of liquid food, but not for penetrating tissues. The hooked tip, although seemingly quite sharp, is rather flexible and too curved for use in piercing.

Both the mandibles and maxillae appear to be too delicate to be of any use in feeding whatsoever. Their short length, in addition to the fact that the mandibles are shorter than the maxillae, would make them unsatisfactory for piercing.

The hypopharynx, being fused to the labium, is immovable. The salivary duct is open throughout its length so that the passage of salivary secretions through the hypopharynx is possible.

It seems, with the evidence laid before us, that male mosquitoes of the species *Anopheles quadrimaculatus* must take liquid food which is readily available through the labrum without the act of piercing to obtain it.

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A CONTRIBUTION TO THE EMBRYOLOGY OF THE MAY BEETLE[1]

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METHODS AND TECHNIQUE

Two species of May beetles, *Phyllophaga fervida* (Fab., 1781) and *P. hirticula* (Knoch, 1801) were used in this embryological study. *P. fervida* is an oblong, shiny, smooth, dark brown beetle about 22 millimeters long (fig. 1), which appeared in early spring. *P. hirticula* (fig. 2) is an oblong, reddish-brown, shiny beetle, 16 to 19 mm. in length, possessing several longitudinal lines of erect hairs on each elytron. It becomes active several weeks after *P. fervida*. By using these two species, adults were available for egg production until the first part of July. Beetles were collected from light traps at Greencastle, Indiana, and also from light traps set up at Purdue University. Oviposition cages were made from glass globes 18 inches tall with diameters of 12 inches. These globes were open at both ends. The top opening of each globe was covered with cheesecloth and the other opening was pressed down into an earthenware saucer filled with two inches of moist compact soil.

Egg laying habits of the May beetle made it very difficult to secure a large number of eggs at exactly the same age; therefore, all stages older than 120 hours were studied with eggs whose age was known only within eight hours. Eggs were collected by sifting the soil from each cage with an 18-mesh screen. The soil passed through the screen, but the eggs, which were embedded in small balls of soil (fig. 4), remained on top of the screen. By gently crushing these lumps, the eggs on the inside were exposed and collected with the aid of a wet camel's-hair brush. They were then placed in two-ounce tin ointment boxes containing wet soil and incubated to the desired stage.

Hot Bouin's fluid was used as a killing and fixing agent. Each egg was punctured with a minute nadel while still in hot Bouin's fluid. Fixed eggs were washed with an acid alcohol solution for eight hours and dehydrated using the tertiary butyl alcohol series as recommended by Johansen (1935). All material to be sectioned was stored in two-inch open-mouthed, glass vials after it had been embedded in a rubber paraffin, bayberry-wax mass. Most eggs were sectioned four at a time, and no attempt was made to orient them in the desired plane before sectioning. After sectioning and staining, only those sections properly oriented were saved for study. Slides were smeared with Mayer's albumen (Kennedy, 1932) before ribbons of sections were added.

Best staining results were obtained using Delafield's haematoxylin

[1]This study was used as a thesis for the degree of Doctor of Philosophy at Purdue University, August 1949.

with Eosin as a counter stain. Mayer's haemalum with a counter stain of Fast Green FCF was used on some of the earlier stages.

THE EGG

When the May beetle egg is laid, it is glistening white, oval in shape, about 2.4 mm. in length and 1.6 mm. in width, and is covered with a sticky substance to which soil particles adhere (fig. 4). As the egg grows older, it becomes spheroidal in shape (fig. 3) and increases in size until it becomes as large as 4 mm. in diameter.

The outer surface of the egg shows the usual slightly raised ridges formed by the ovarian follicle cells. In a section, the chorion appears as a single membrane made up of two laminae (fig. 10). Beneath the chorion lies the vitelline membrane (fig. 10) which is very thin and noncellular. Spermatozoa pass through the chorion by means of micropyle openings. Micropyles are located on both ends of the egg, and they may be volcano-like or saucer-like in structure (fig. 9).

Just inside the vitelline membrane lies a layer of protoplasm (fig. 11) 6 to 9 microns thick which exists in the egg from the time of oviposition until the formation of the blastoderm. This superficial protoplasm is known as periplasm. In the posterior polar region it thickens to form a dense cap (fig. 5) that, at one hour, expands to form a saucer-shaped network of protoplasm (fig. 6). The periplasm is continuous with a reticulum of protoplasmic strands which ramify throughout the inner portion of the egg (fig. 8). Contained within the reticulum are the vitelline spheres or granules which vary greatly in size (fig. 9). Short rods of protoplasm are sometimes present at the polar region where the sperm enters the egg (fig. 7). These appear to be parts of disintegrating spermatozoa.

MATURATION AND FERTILIZATION

The location of the pronucleus at the time of oviposition has not been determined with any degree of certainty. In some eggs, the pronucleus is observed in the periphery of the egg in the polar region. In others it is not observed at all, probably due to improper staining of the nuclei. Four hours after oviposition, the pronucleus is found in the periphery of the egg (fig. 10) where it gives off the first polar body. It then migrates toward the center of the egg and gives off a second polar body. At six hours the first polar body, which remains at the periphery of the egg, divides and forms another polar body. This polar body is pushed out of the cytoplasmic periphery to a position under the vitelline membrane (fig. 12) where it remains in a cytoplasmic cell until it disintegrates. The remaining polar bodies (fig. 13) migrate around the yolk granules and, after increasing greatly in size, disintegrate and are absorbed by the yolk.

As the egg is deposited, the spermatozoa enter the micropyles (fig. 9). Their heads and tails separate, and the heads become lodged in a cytoplasmic mass immediately below the micropyles (fig. 8). As more than one sperm was found in each egg, polyspermy is indicated. Fertilization occurs almost in the center of the anterior portion of the egg.

CLEAVAGE AND BLASTODERM FORMATION

Following the fusion of the gametes and the formation of the zygote at 10 hours, meroblastic cleavage begins (figs. 15 and 16). Various

stages of mitotic division are shown in figures 14a, 14b, and 14c. All cleavage nuclei are connected by protoplasmic strands to the reticulum. The first group of nuclei moves together to the periphery of the egg and passes into the cytoplasmic pockets (fig. 11) formed by the periplasm. These nuclei, containing 21 chromosomes each, first reach the surface of the egg in the equatorial region (fig. 20) as reported by Wray (1937) and Heider (1889). Synchronous cleavage division occurs during migration. Division of the nuclei continues after they enter the periphery of the egg. When the nuclei are correctly spaced for cell formation, cell walls are laid down enclosing each nucleus with its adjacent cytoplasm. The egg now enters the blastodermal stage. Not all cleavage nuclei reach the periphery of the egg and enter into the formation of the blastoderm. Some nuclei are left behind and form primary vitellophags (fig. 18) which disappear shortly after the completion of the blastoderm.

GERM BAND AND GERM CELL FORMATION

The appearance of the blastoderm begins to change as the cells continue to divide. On the ventral side at the anterior end of the egg, cell division proceeds very rapidly (fig. 17) and soon a cap of cells is produced (fig. 19) which is similar in appearance to the mesenteron rudiment described by Kessel (1939) in his work on the flea, and to the head lobe which Johannsen and Butt (1941) described under their general discussion of embryology. At 40 hours, the cells and nuclei of this polar cap appear crushed and irregular in shape and are surrounded by elongated masses of protoplasm (fig. 19). Two circular masses of granular material resembling yolk syncitia as described by Nelson (1915) also appear along the inner edge of the cap at 40 hours (fig. 21).

At 48 hours, cells on the dorsal side of the egg appear crowded (fig. 26) and greatly reduced in size while the cells on the ventral side appear well spaced, elongated, and increased in size (fig. 24). At 54 hours, the polar cap moves farther down on the ventral side and small groups of nuclei (fig. 22) leave the blastoderm on the dorsal side. This might indicate that the cells on the dorsal side are migrating along the periphery and, also, out into the yolk of the egg toward less crowded areas. Migrating nuclei groups (fig. 25) in the yolk are each composed of from 4 to 16 nuclei. Butt (1936) in his work on the snout beetle observed single nuclei, which he termed secondary vitellophags, moving in from a crowded germ band in much this same manner, but the vitellophags he reported disintegrated in the yolk. Nuclei groups, which form in the May beetle egg, apparently do not disintegrate but move through the yolk granules accumulating protoplasm as their nuclei increase in size. The cells on the ventral side send out cytoplasmic streamers at 64 hours (fig. 25) giving the blastoderm a moss-like appearance. At 68 hours, nuclei groups which have been migrating around the yolk separate into individual nuclei and appear to re-enter the periphery of the egg (fig. 27) along the mid-ventral line where they assist in the formation of the germ band. The direction of migration is indicated by the small particles of protoplasm streaming behind the nuclei.

During the formation of the germ band, germ cells with very prominent nuclei and unusually clear cytoplasm appear at the posterior

end of the egg (fig. 29). During blastokinesis some of these cells, starting their migration to the fifth body segment for the formation of the gonads (fig. 52), appear at the posterior end of the embryo on the mesodermal side (fig. 39).

EMBRYONIC MEMBRANES AND BLASTOKINESIS

Two membranes form as the germ band develops. One is called the serosa and the other the amnion. Both are made up of squamous type cells not involved in the formation of the germ band. The amnion covers and is continuous with the germ band. The serosa covers the vitelline membrane and has no connection with the germ band after its formation.

Embryonic membrane formation begins at 78 hours with a shallow indentation (fig. 28) at the anterior end of the germ band above the polar cap. The anterior margin of this indentation (fig. 31), the anterior amniotic fold, grows posteriorly and laterally along the side of the egg. At 90 hours another indentation occurs on the posterior end of the germ band when the anterior amniotic fold has covered two-thirds of the germ band (fig. 34). The posterior end of this indentation forms the posterior amniotic fold and advances to meet the anterior amniotic fold. There is no partial involution of the embryo as in the Odonata. The two folds join in the posterior region and, as they join, the intervening walls rupture. The inner layers of the folds fuse to complete the formation of the amnion, and the outer layers fuse to form the serosa. When completed at 94 hours, the serosa is composed of the two outer layers of the amniotic folds and the blastodermal covering of the egg. The amnion is composed of the inner two layers of the amniotic folds and is continuous with the germ band.

Both the serosa and the amnion are still complete at 144 to 152 hours. Between 168 and 176 hours, the amnion and the serosa fuse together directly over the amniotic cavity to form the amniotic-serosal membrane. At the end of the tenth day this membrane ruptures and is pulled upward toward the dorsal surface of the egg (fig. 43). When the dorsal wall of the embryo is almost completed by the growth of the ectoderm and the middle layers between 288 and 296 hours, the membrane assumes an umbrella-like appearance and descends or is pressed into the yolk where it is dissolved (figs. 53 and 56). This membrane is called a dorsal organ.

Two other folds, called pleuropodia, which have no connection with either the amnion or the serosa, are formed directly from the ectoderm of the embryo. Each is composed of a single layer of low type columnar cells and is similar to the paired evanescent embryonic evaginations of the first abdominal segment reported by Graber (1889) and Wheeler (1889a). Johannsen and Butt (1941) believe pleuropodia serve as organs of excretion or secretion during embryonic life. Blunck (1914) believes they furnish a hatching enzyme. In the May beetle embryo, the pleuropodia attain a maximum development between 192 and 200 hours (fig. 49). They then decrease in size and disappear as the embryo completes its development.

As the embryonic membrane are forming, the posterior and anterior ends of the germ band lengthen. The anterior end moves half the distance around the periphery of the anterior pole. The posterior end

passes down the ventral side, around the posterior pole, and anteriorly on the dorsal side until, at 120 hours, it has covered one-third the distance between the poles (fig. 37). By the end of 144 hours, the posterior and anterior ends of the germ band have withdrawn to positions along the midventral line in the polar regions (fig. 38). This extension and retraction of the germ band is called blastokinesis.

THE MESODERM

As the germ band is being covered by the amnion, the mesodermal layer is formed by nuclei migrating inwardly into a cytoplasmic layer on the inner edge of the germ band. This manner of mesodermal layer formation seems to be identical to that described by Wheeler (1889b) in *Blatta*. There is some indication that a very shallow mesodermal tube as reported by Heider (1889) in *Hydrophilus* is formed at 78 hours at the anterior end of the germ band prior to the formation of the mesodermal layer (fig. 30). Soon after formation, the mesodermal layer divides into two lamellae. This division starts at the lateral edges and proceeds inwardly (fig. 32). Eighteen pairs of coelomic sacs (fig. 35), connected intrasegmentally and intersegmentally by very narrow passageways, are formed on the lateral edges of the mesoderm between the two layers. One pair of coelomic sacs is located forward of the stomodaeal invagination in the antennal segment; the remaining pairs are located posterior to the stomodaeal invagination. Intrasegmental passageways exist for only a short time due to the reorganization and proliferation of mesodermal cells (fig. 33) between the coelomic sacs. One layer of cells separates from the walls of the coelomic sacs to form splanchnic mesoderm. Muscles of the alimentary canal are formed from this layer. All other mesodermal cells congregate on the outside layer or ectoderm and form the somatic mesodermal tissue. Muscles of the body wall and appendages arise from this tissue. At 168 and 176 hours, the sides of the embryo extend one-fourth the distance around the yolk. Cardioblasts and blood cells are now conspicuous (fig. 40) between the somatic and splanchnic mesoderm. A group of mesodermal cells for the formation of heart muscles appear directly under the cardioblasts.

Between 288 and 296 hours, the lateral layers, now one cell in thickness, have almost encircled the yolk; the amnio-serosal membrane has folded into the yolk forming a dorsal organ (fig. 53); and the cardioblasts have elongated and curved. Heart formation is completed (figs. 50, 54, and 57) just prior to hatching at 392 hours.

THE ENTODERM

Entoderm formation begins at 120 hours with two indentations of the germ band as the embryo reaches its maximum length in blastokinesis (fig. 37). One of these indentations occurs at the anterior end just below the polar cap or head lobe; the other at the posterior end, slightly forward of the point where the amnion and germ band meet. The entoderm is formed from cell masses which migrate to the inner side of the germ band at these indentations. Ribbons of cells running lateroventrally of the yolk (fig. 38) and originating at these cell masses, now called anterior and posterior mesenteron rudiments, appear between 144 and 152 hours. The ends of these ribbons approach each other from opposite directions (figs. 41 and 42), meet and fuse

to connect the posterior and anterior mesenteron rudiments. By lateral proliferation, these ribbons replace the layers of mesodermal cells over the epineural sinus and form the mid-gut. The replaced mesodermal cells form blood cells and pass into the body cavity.

THE ECTODERM

The layer of cells remaining after mesodermal formation is called the ectodermal layer. One of the most important ectodermal derivatives is the nervous system. Active proliferation of specialized ectodermal cells called neuroblasts (fig. 33) forms two neural ridges which extend longitudinally along the midventral line from the stomodaeum to the proctodaeum. The groove formed between these ridges is called the neural groove. Neuroblasts also form the middle cord by proliferation from the floor of the neural groove. The layer of ectoderm covering the neuroblasts forms the epidermis.

At segmentation the neural ridges are constricted into segmental divisions. All segmental ganglia are connected successively by connectives (figs. 45 and 55), and each pair of segmental ganglia are connected transversely by commissures. The commissures and neural ridges fuse along the midline, but connectives remain distinct throughout embryonic development.

The central nervous system consists of twenty pairs of ganglia at 216 to 224 hours, but by the end of 16 days the last two pairs of abdominal ganglia have fused leaving a total of nineteen pairs of ganglia. The first pair of ganglia form the protocerebrum (figs. 45 and 48) of the ocular segment, and are connected by one commissure. The second pair of ganglia, (figs. 45 and 46) forming the deutocerebrum, innervates the antennae. These are the only two pairs of ganglia that originate anteriorly to the stomodaeum. The tritocerebrum (fig. 44) appears to be formed from the lateral connectives as in the flea (Kessel, 1939) and is considered to be ventral to the stomodaeum, because its transverse commissure passes below the esophagus (fig. 47). A nerve cord originates at each ganglion of the tritocerebrum and extends forward and above the stomodaeal invagination. Each of these cords have a clavate mass at its distal end (fig. 46) believed to be a frontal ganglion.

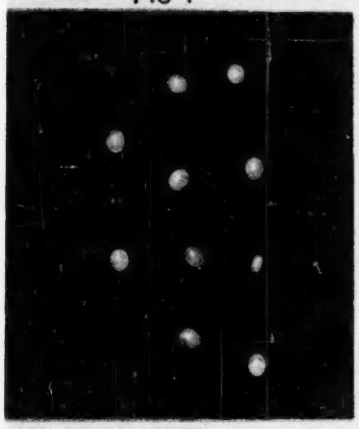
The fourth, fifth, and sixth pairs of ganglia of the mandibular, maxillary, and labial segments fuse to form the subesophageal ganglion (fig. 45). The seventh, eighth, and ninth pairs, the thoracic ganglia, do not fuse and are distinct at all stages of embryonic development. Eleven pairs of ganglia are present in the abdominal region; ten are distinct at 384 hours as the last two pairs fuse.

The tracheal system is another derivative of the ectodermal layer; it arises from paired invaginations (fig. 56) which sink below the surface, branching again and again to form a complex respiratory system.

The stomodaeum and the proctodaeum are formed by the deepening of the indentations in the germ band (figs. 41 and 42) which appear during the formation of the entoderm. Both are considered to be ectodermal in origin. The ectoderm gives rise to a number of other structures which have not been considered in detail during this study. Some of these are the tentorium, labial glands, the corpora allata, and perhaps the Malpighian tubules.

FIG 1

FIG 2



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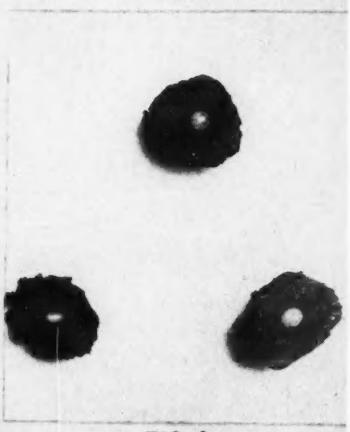

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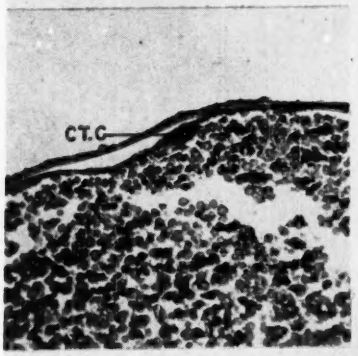


FIG 5

FIG 6

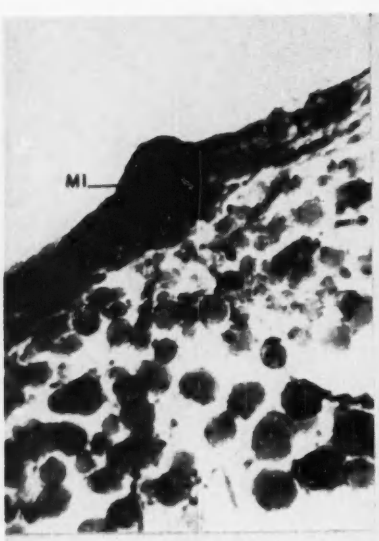


FIG 7

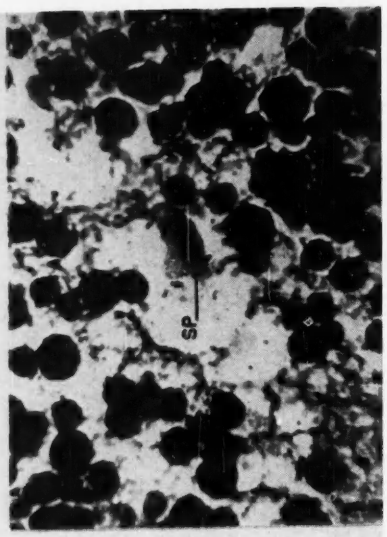


FIG 8

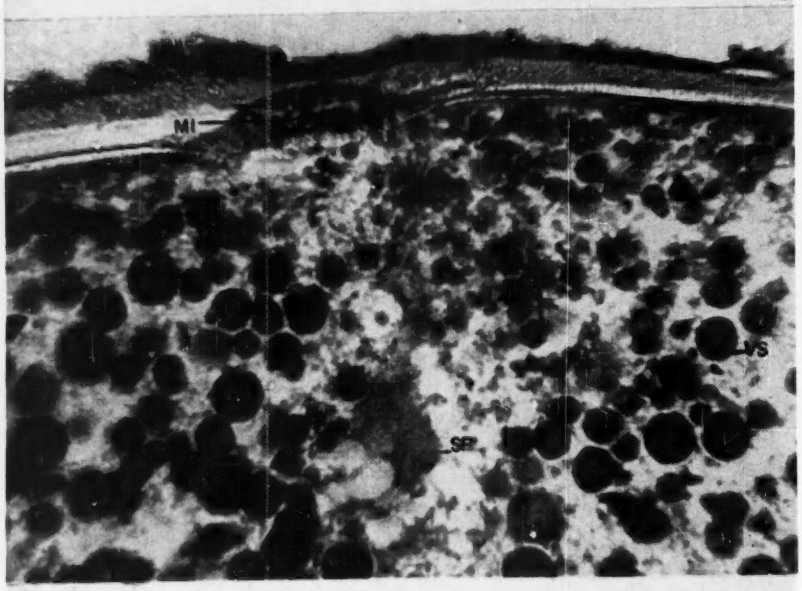


FIG 9

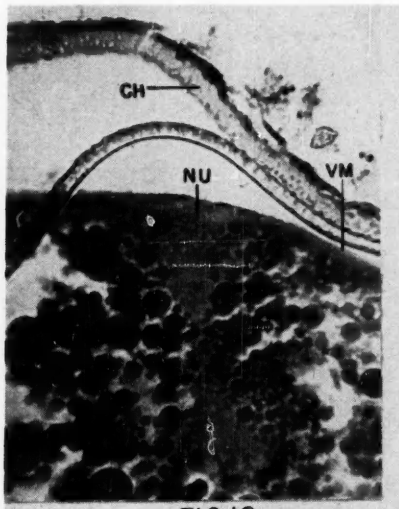


FIG 10

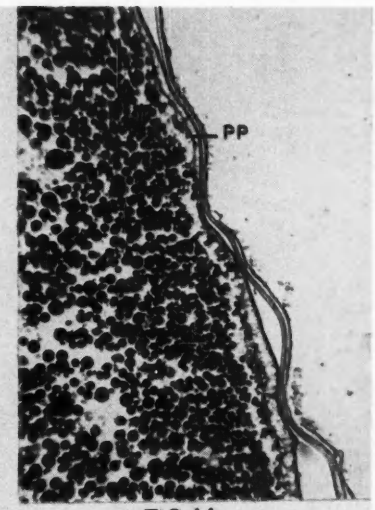


FIG 11

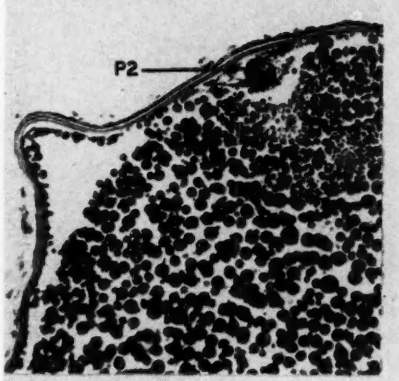


FIG 12

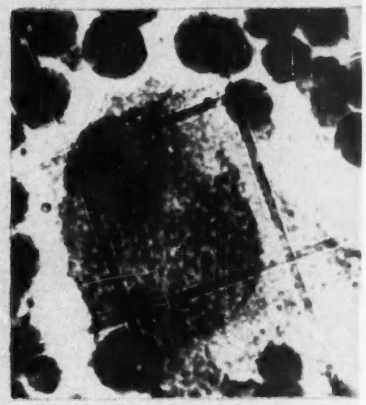
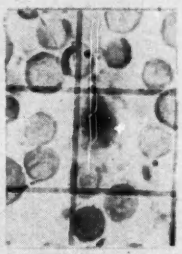


FIG 13

FIG 14A



B

C

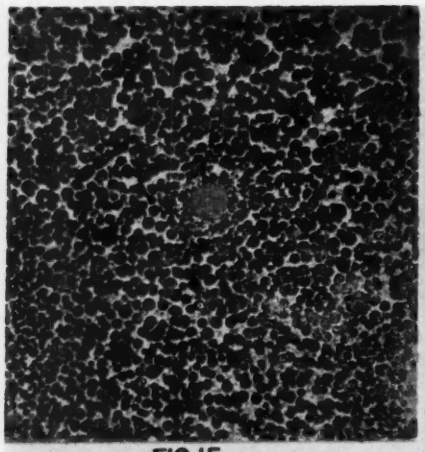


FIG 15

FIG 16

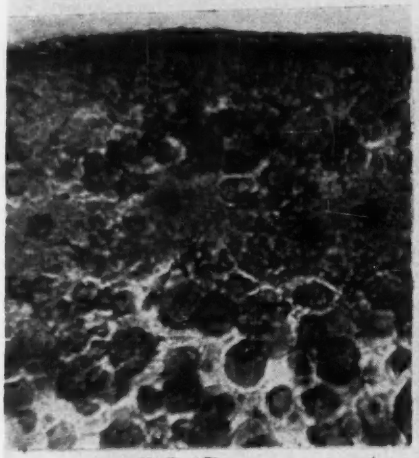


FIG 17

FIG 18

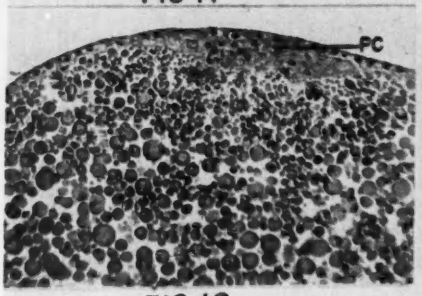
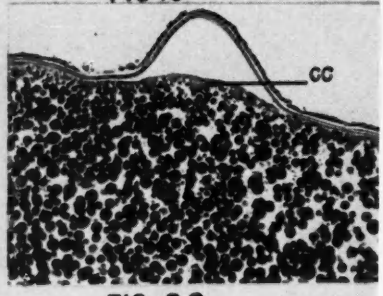


FIG 19



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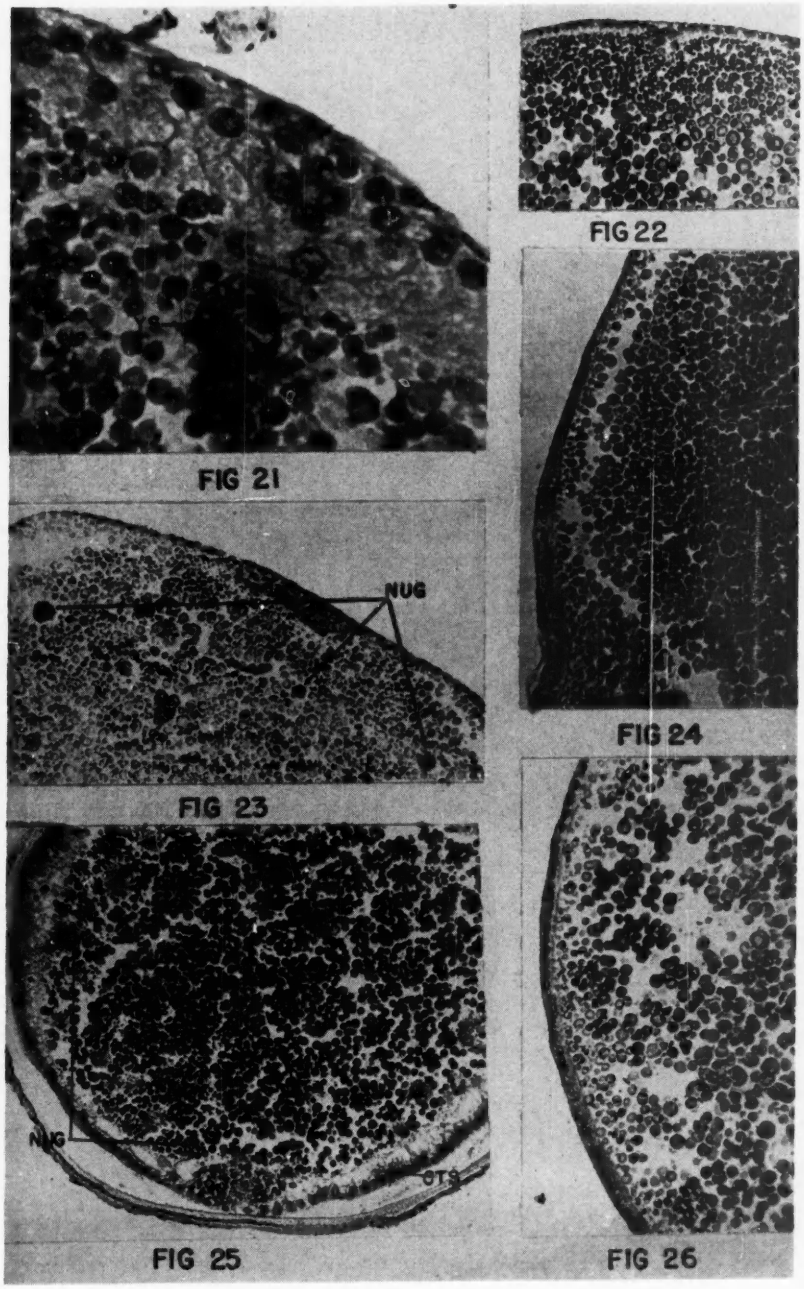
FIG 21
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FIG 24
NUC
OTS
FIG 25
FIG 26

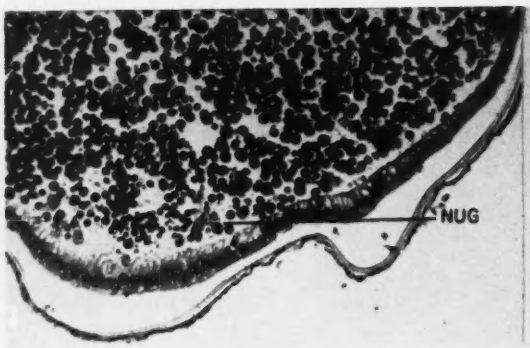

FIG 27

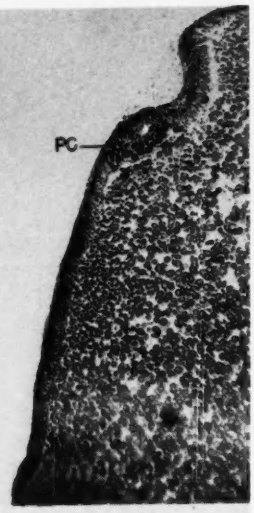

FIG 28

FIG 29

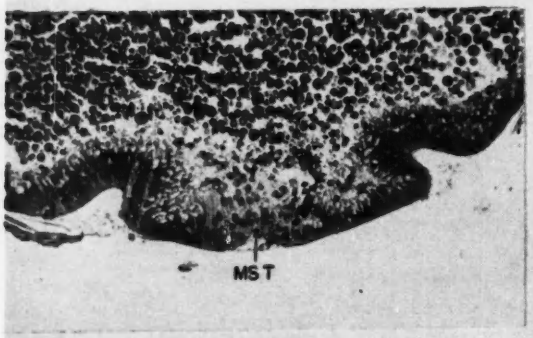

FIG 30

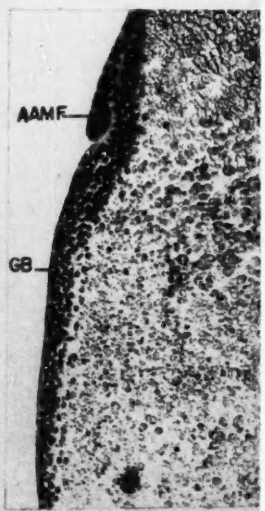

FIG 31

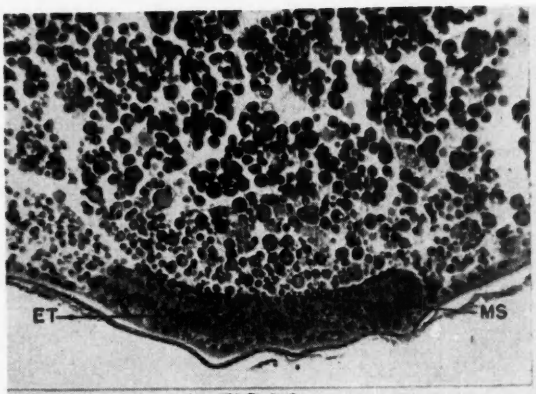

FIG 32

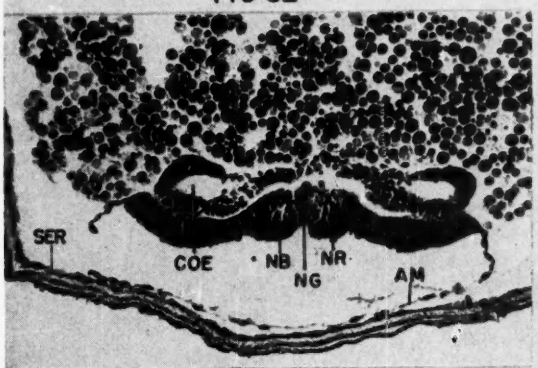

FIG 33

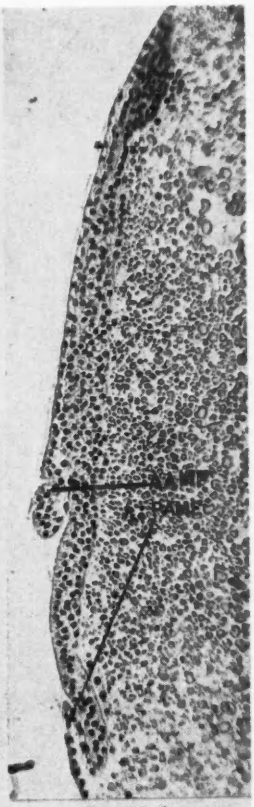

FIG 34

FIG 35

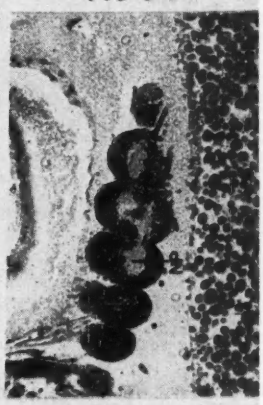

FIG 36

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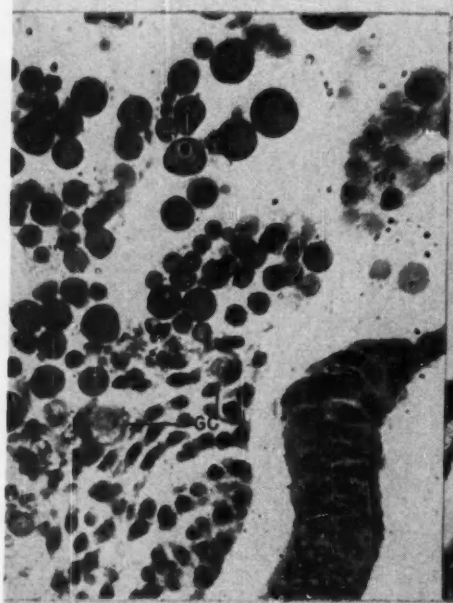


FIG 39

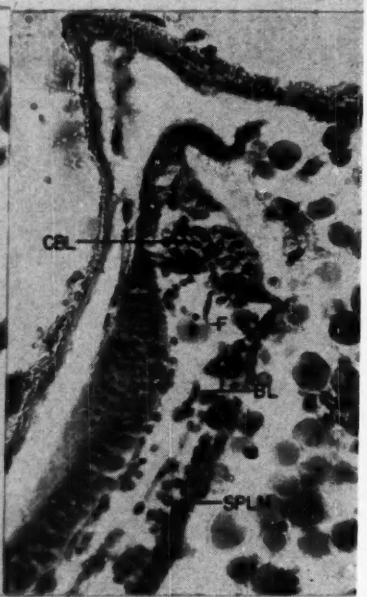
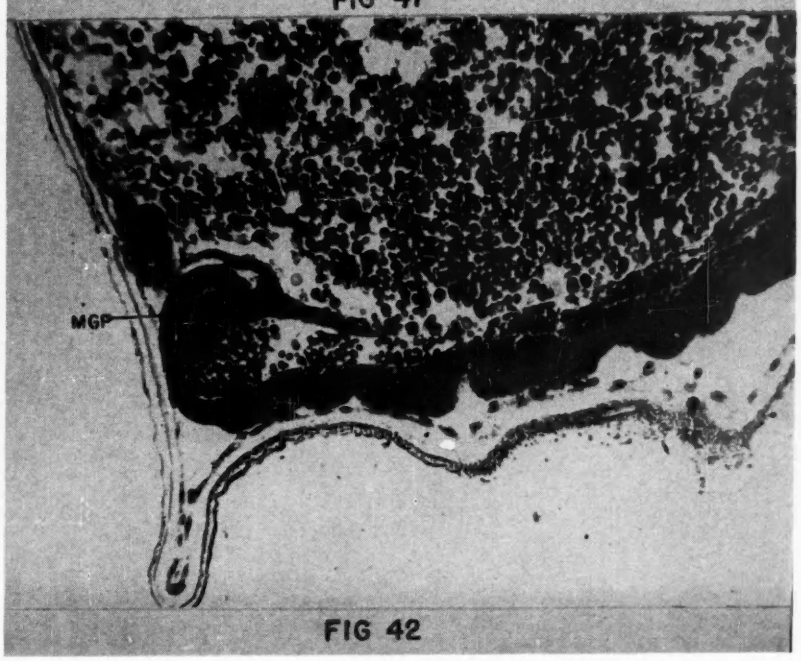


FIG 40

FIG 41



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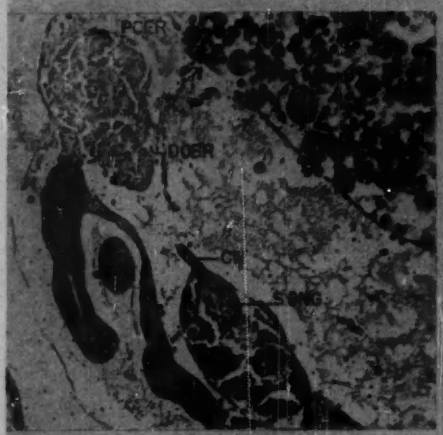

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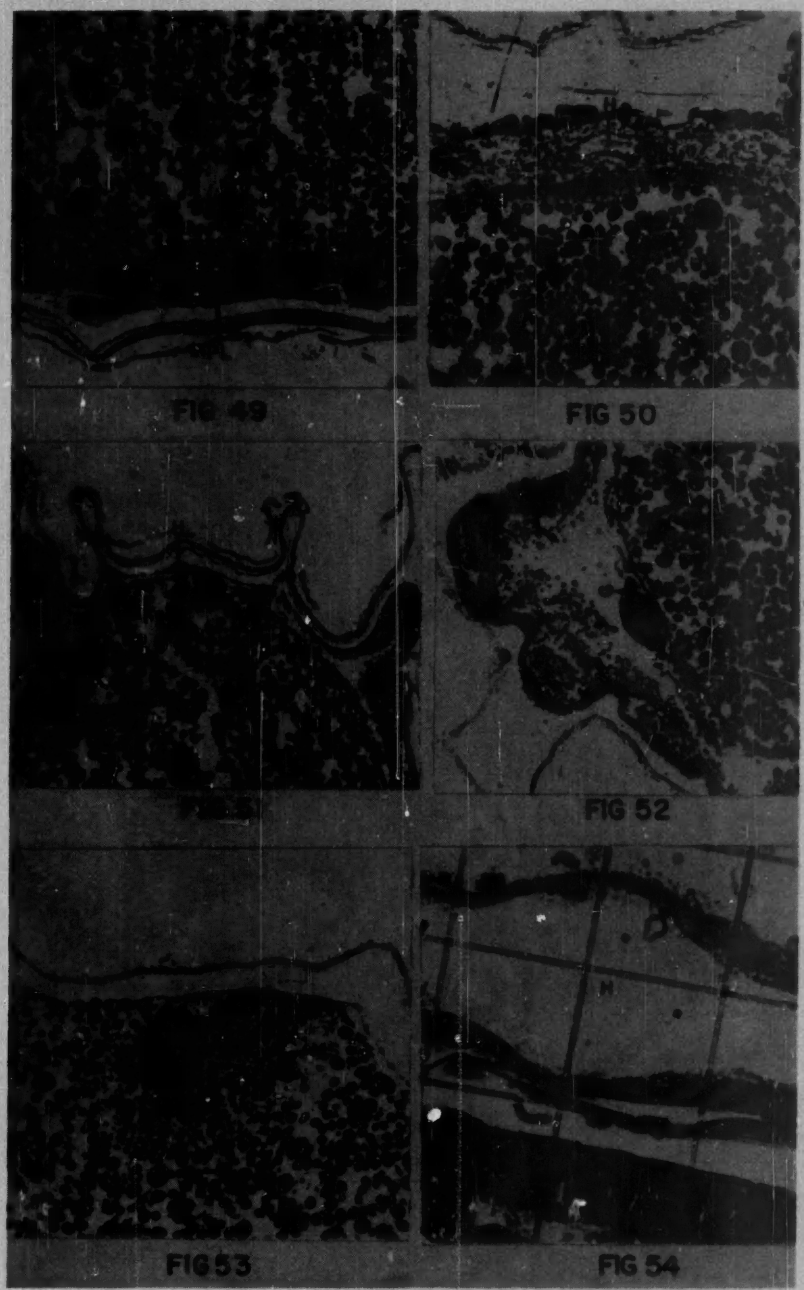
FIG 47

FIG 48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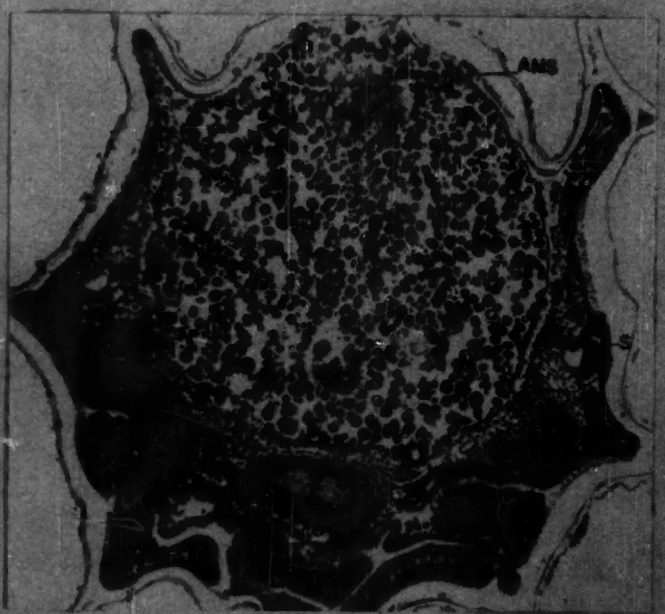

FIG 56

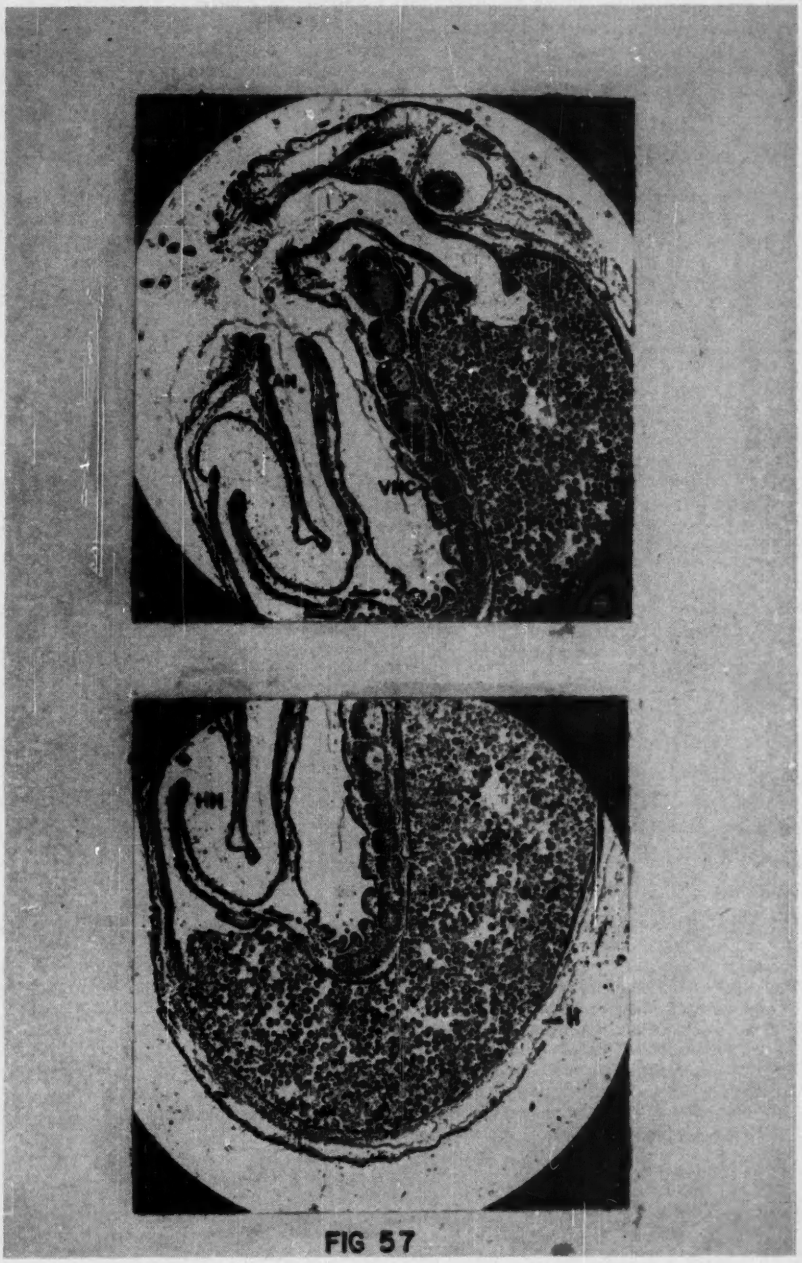

FIG 57

EXPLANATION OF ABBREVIATIONS

am, amnion; a. am. f., anterior amniotic fold; am. s., amniotic-serosal membrane; an, anus; b, brain; bl, blood cell; cbl, cardioblast; cc, cleavage nucleus; ch, chorion; cm, commissure; cn, connective; coe, coelomic sac; ct. c., cytoplasmic cap; ct. s., cytoplasmic streamers; d. cer., deutocerebrum; et, ectoderm; f, fat bodies; f. gng., frontal ganglion; g, gonad; gb, germband; g. c., germ cell; h, heart; hn, hind intestine; m, mouth; ms, mesoderm; ms. t., mesodermal tube; mg, midgut; mg. p., posterior mesenteron rudiment; mg. a., anterior mesenteron rudiment; mi, micropyle; nb, neuroblast; n. r., neural ridge; n. g., neural groove; np, neuropile; nu, nucleus; nu. g., nuclei group; oe, esophagus; p2, second polar body; p. c., polar cap; p. cer., protocerebrum; pl., pleuropodia; p. am. f., posterior amniotic fold; pp, periplasm; s, spiracles; ser, serosa; s. gng., subesophageal ganglion; sp, sperm; spl. m., splanchnic mesoderm; s. s. p., saucer-shaped protoplasm; t. cer., tritocerebrum; v. m., vitelline membrane; vit, vitellophags; v. n. c., ventral nerve cord; v. s., vitelline spheres; y. s., yolk syncitia.

EXPLANATION OF PLATES

Plate I

Fig. 1. *Phyllophaga fervida* Fab. (× 2).

Fig. 2. *Phyllophaga hirticula* Knoch (× 2). Photographs for Figs 1 and 2 kindly contributed by Dr. P. Luginbill, Sr.

Fig. 3. Eggs of the May beetle, *Phyllophaga fervida*. The elongated egg was freshly laid; the others were two weeks old.

Fig. 4. Eggs of the May beetle, *Phyllophaga fervida*, in clumps of earth in which they were laid. Photographs for Figs. 3 and 4 contributed by Prof. J. J. Davis. They were taken in 1910 when he was with the Bureau of Entomology and Plant Quarantine.

Fig. 5. Longitudinal section at 0 hours just before oviposition showing the cytoplasmic cap in the polar region. (× 110).

Fig. 6. Longitudinal section through posterior half of egg showing saucer-shaped mass of protoplasm at 1 hour. (× 110).

Plate II

Fig. 7. Longitudinal section at 2 hours through the polar region showing rods of protoplasm just under a micropyle. (× 625).

Fig. 8. Sagittal section at 2 hours through the polar region showing head of sperm resting among the protoplasmic network. (× 700).

Fig. 9. Sagittal section through posterior end of egg showing sperm resting directly under saucer-shaped micropyle and vitelline spheres. (× 600).

Plate III

Fig. 10. Transverse section at 4 hours showing two layers of the chorion and the nucleus at the periphery of the egg. (× 930).

Fig. 11. Sagittal section at 14 hours showing the periplasmic layer beneath the vitelline membrane. At one end the periplasm is breaking up to form pockets to receive the cleavage nuclei. (× 160).

Fig. 12. Transverse section at 6 hours showing a second polar body in its cytoplasmic pocket after being pushed out of the yolk. (× 500).

Fig. 13. Sagittal section of a polar body at 12 hours. This polar body is beginning to disintegrate. (× 900).

Fig. 14. Stages of mitosis: a. metaphase, (× 900); b. anaphase, (× 900); c. telophase, (× 900).

Plate IV

Fig. 15. Sagittal section at 12 hours, just after fusion of the male and female nuclei. (× 166).

Fig. 16. Transverse section at anterior end of egg at 14 hours showing the beginning of cleavage division. (× 140).

Fig. 17. Sagittal section through anterior end at 18 hours. Nuclei are beginning rapid cell division to form polar cap. (× 800).

FIG. 18. Sagittal section showing cleavage nuclei and primary vitellophags. (× 140).
FIG. 19. Sagittal section at 40 hours through the polar cap at the anterior end of the egg. (× 250).
FIG. 20. Sagittal section at 24 hours showing cleavage nuclei immediately after arrival at the periphery in the equatorial region. (× 160).

PLATE V

FIG. 21. Sagittal section through the polar cap at 40 hours showing two large protoplasmic bodies which are believed to be yolk syncitia. (× 625).
FIG. 22. Sagittal section of the blastoderm at 54 hours showing the formation of a "nuclei group." (× 150).
FIG. 23. Longitudinal section through polar cap after "nuclei groups" have been formed. (× 160).
FIG. 24. Sagittal section showing ventral side of the blastoderm at 48 hours. (× 190).
FIG. 25. Transverse section at anterior end of an egg 64 hours old to show nuclei groups near the periphery of the egg. Cells of blastoderm have cytoplasmic streamers. (× 135).
FIG. 26. Sagittal section at 48 hours of the blastoderm before "nuclei group" formation to show crowded condition of the nuclei on the dorsal side. (× 190).

PLATE VI

FIG. 27. Transverse section at 68 hours near anterior end of the egg showing "nuclei groups" breaking up and re-entering the periphery of the egg. (× 135).
FIG. 28. Sagittal section through ventral side of the egg at 78 hours showing the completed germ band. The indentation above the polar cap is the beginning of the formation of the amnion. (× 100).
FIG. 29. Transverse section at 58 hours showing germ cells at posterior pole during germ band formation. (× 320).
FIG. 30. Transverse section at anterior end of germ band at 78 hours showing shallow mesodermal tube formation. (× 150).
FIG. 31. Sagittal section through germ band at 84 hours showing amniotic fold starting its migration toward the posterior end. (× 100).

PLATE VII

FIG. 32. Transverse section near the middle of the egg showing the ectodermal and mesodermal layers. The mesodermal layer has divided into two lamellae, and coelomic sacs are beginning to form at their lateral edges. (× 160).
FIG. 33. Transverse section near the middle of the egg at 120 hours showing coelomic sacs, neural ridges, neuroblasts, and neural groove. (× 135).
FIG. 34. Sagittal section through the germ band at 90 hours showing the anterior amniotic fold approaching the posterior fold. (× 100).
FIG. 35. Longitudinal section of egg the same age as Fig. 33. (× 135).
FIG. 36. Longitudinal section showing neuropile of ganglia. (× 110).

PLATE VIII

FIG. 37. Sagittal section of the embryo at 120 hours showing coelomic sacs and indentations at the anterior and posterior ends which furnish cells for the formation of the anterior and posterior mesenteron rudiments. (× 55).
FIG. 38. Sagittal section of the embryo between 144–152 hours showing the anterior mesenteron ribbon being formed on the mesenteron rudiment. (× 55).
FIG. 39. Sagittal section of the posterior end of the embryo at the same stage as Figure 37 to show cells with large nuclei and clear cytoplasm resting on the mesodermal layer. These are believed to be germ cells. (× 600).
FIG. 40. Transverse section through the middle of the embryo between 168–176 hours showing splanchnic mesoderm, blood cells, cardioblasts, and fat body. (× 500).

PLATE IX

FIG. 41. Sagittal section of the anterior end of the embryo between 150–158 hours showing the anterior mesenteron rudiment attached to the stomodaeal invagination and sending out its mesenteron ribbon. (× 150).

EXPLANATION OF ABBREVIATIONS

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FIG. 42. Sagittal section of the posterior end of the embryo between 150–158 hours showing the posterior mesenteron rudiment attached to the proctodaeal invagination and sending out a mesenteron ribbon. (× 150).

PLATE X

FIG. 43. Transverse section of the dorsal side between 240–248 hours showing amniotic-serosal membrane migrating to the dorsal side of the egg to be absorbed. (× 160).
FIG. 44. Longitudinal section between 288–296 hours showing paired tritocerebrum. (× 110).
FIG. 45. Longitudinal section between 240–248 hours showing the protocerebrum, deutocerebrum, subesophageal ganglion, and connectives. (× 130).
FIG. 46. Longitudinal section between 288–296 hours through stomodaeal invagination showing deutocerebrum on each side and frontal ganglia. (× 110).
FIG. 47. Longitudinal section showing commissure running under the stomodaeum invagination connecting the ganglia of the tritocerebrum. (× 110).
FIG. 48. Longitudinal section between 288–296 hours showing protocerebrum on each side of the stomodaeum. (× 110).

PLATE XI

FIG. 49. Sagittal section of the pleuropodia between 192–200 hours. (× 110).
FIG. 50. Transverse section between 384–392 hours showing heart on dorsal side of embryo. (× 115).
FIG. 51. Transverse section of dorsal side of developing embryo between 288–296 hours showing beginning of heart formation. (× 110).
FIG. 52. Transverse section showing gonad attached to splanchnic layer. (× 110).
FIG. 53. Transverse section of dorsal side of embryo at 288–296 hours showing absorption of the amniotic-serosal membrane. (× 110).
FIG. 54. Longitudinal section of the heart at the anterior end of the embryo between 384–392 hours. (× 1000).

PLATE XII

FIG. 55. Longitudinal section of the head showing connectives leaving subesophageal ganglion, brain, mouth, and esophagus. (× 130).
FIG. 56. Transverse section between 288–296 hours showing paired invaginations for spiracle formation and disintegrating amniotic-serosal membrane. (× 110).

PLATE XIII

FIG. 57. Sagittal section of fully developed embryo showing heart, mid-gut, ventral nerve cord, part of brain and frontal ganglion, mouth, esophagus, hind intestine, and anus. (× 50).

SUMMARY

Phyllophaga fervida (Fab. 1781) and *Phyllophaga hirticula* (Knoch 1801) are the species used in this embryological study. Chorions of all eggs were punctured to increase permeability. Rubber paraffin with some bayberry wax added was used as the embedding mass.

The May beetle egg is of the centrolecithal type, oval in shape, and averages 2.4 mm. in length. Spermatozoa enter through micropyles at the ends of the egg. Each egg possesses a very prominent periplasmic membrane which is continuous with a reticulum of protoplasmic strands that ramify throughout the inner portion of the egg.

Maturation division occurs in or around the anterior periplasm of the egg and fertilization takes place almost in the center of the anterior end. Meroblastic cleavage begins immediately after fertiliza-

tion. Synchronous division occurs in cleavage nuclei as they move outward. Cleavage nuclei first reach the periphery of the egg in the equatorial region. The periplasmic membrane forms pockets to receive the cleavage nuclei. After cell walls are laid down around the cleavage nuclei, the egg enters the blastoderm stage. Primary vitellophags are formed from cleavage nuclei which remain behind among the yolk granules.

A polar cap is formed at the anterior end of the egg. Rapid cell division on the dorsal side of the blastoderm apparently forces groups of nuclei to migrate along the periphery of the egg and out into the yolk. Nuclei groups in the yolk eventually return to the periphery along the midventral line to aid in germ band formation.

The amniotic and serosal layers are formed by the fusion of double folds growing out of the anterior and posterior margins of indentations at each end of the germ band. These two membranes later fuse together and migrate into the yolk to form the dorsal organ. Pleuropodia attain their maximum development at the end of the eighth day. As the embryo completes its development they decrease in size and disappear.

Blastokinesis consists of the extension and retraction of the germ band along the periphery of the egg. There is no involution of the embryo.

The mesoderm is formed by nuclei migration inward from the germ band. There is some indication that a shallow mesodermal tube is formed at the anterior end of the germ band. Eighteen pairs of coelomic sacs are formed in the mesoderm. One pair is located forward of the stomodaeal invagination.

The entoderm is formed by active proliferation of cell masses called mesenteron rudiments which are produced by cells migrating inwardly from the germ band.

The ectoderm is the lower layer of cells remaining after mesodermal formation. One of its main derivatives is the central nervous system which is formed from the neural ridges and the middle cord. It has twenty pairs of ganglia. The first pair of ganglia forms the protocerebrum, the second pair the deutocerebrum. These are the only two pairs of ganglia which are anterior in position to the stomodaeal invagination. The third pair, the tritocerebrum, which appears to be formed from the lateral connectives, moves forward and fuses with the protocerebrum and deutocerebrum to form the brain. Ganglia in the gnathal segments fuse to form the subesophageal ganglion. The three thoracic ganglia remain distinct. Eleven abdominal ganglia are found in the abdominal region in the early embryo, but only ten remain in the mature embryo as the tenth and eleventh ganglia fuse.

The tracheal system is another derivative of the ectodermal layer. It arises from paired invaginations. The stomodaeum and proctodaeum are formed by the deepening of indentations in the germ band which appear at the beginning of ectoderm formation.

Germ cells are first distinguishable at the posterior pole at the time of germ band formation. They next appear above the mesodermal layer at the posterior end of the germ band during blastokinesis. Germ cells later group together to form gonads in the fifth body segment.

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ATLAS OF THE SCALE INSECTS OF NORTH AMERICA, VOL. VI, by GORDON FLOYD FERRIS. vii+228 pp., 85 full page figures. Stanford Univ. Press. 1953. Price, $7.50.

This volume concludes the part devoted to the Pseudococcidae, begun in volume 5, and the pagination and figure numbering runs consecutively with that of the preceding volume (*cf.* Ann. Ent. Soc. Amer., 44(1): 168, for review). An index is given to cover both volumes, and a new and more complete generic key, as well as some revised specific keys, are presented. Five new genera are proposed, and new species are described. The author does not make any pretense to attempt completeness in this work, but leaves "the monotonous and nerve-wracking task of illustrating and describing these [new] species" to his successors.

Two additional volumes will complete the series, if publication can be financed, which we certainly and sincerely hope will be the case. This work has truly been described as "monumental"; it would be tragic for it to remain uncompleted because of lack of financial support.—M. T. J.

THE MEXICAN SPECIES OF THE GENUS POMPILUS
(Hymenoptera, Pompilidae)

HOWARD E. EVANS
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The genus *Pompilus* is represented by twenty species in the United States and Canada. In a recent revisionary study of the genus,[1] four of these were recorded from Mexico, and a fifth described from there; a total of nine Mexican specimens were then known to me. On a collecting trip through the Nearctic parts of Mexico during the summer of 1951, Dr. Paul D. Hurd, Jr., of the University of California, and the author[2] collected 108 specimens of the genus *Pompilus*. As a result of these new collections, reported upon in this paper, the total number of species and subspecies known from Mexico is increased to sixteen. (Although Cameron records 51 species from Mexico in the "Biologia Centrali-Americana," it seems probable that none of these belong to the genus as it is now understood.)

This collection is of considerable interest for at least two reasons other than the fact of more than tripling the number of forms known from Mexico. First, a new and highly interesting subgenus, *Xenopompilus*, has been discovered. Although probably closest to *Hesperopompilus*, this subgenus lacks a tarsal comb and has a number of unusual features. Secondly, the subgenus *Ammosphex* has been shown to be abundantly represented at high altitudes in many parts of Mexico. The species of *Ammosphex* occurring in Mexico appear to be the same as those occurring in the western United States, but geographic isolation has apparently brought about the formation of several distinct subspecies in various parts of the Mexican highlands. These are best evidenced by differences in the male terminalia, sometimes fairly striking, although in other respects these races can scarcely be recognized as distinct.

The key which follows includes all the subgenera of *Pompilus* known or likely to occur in Mexico. Only three of these are treated further in this paper (*Perissopompilus*, *Xenopompilus*, and *Ammosphex*). *Hesperopompilus* is known to occur in Baja California, but I have seen no additional specimens of this subgenus since the publication of my study of the Nearctic Pompilini, and hence have omitted it from the present paper. The same is true of *Xerochares*. However, a specimen of the single known species of *Xerochares*, *expulsus* Schulz, was collected at Antigua, Guatemala, in August, 1951, by Dr. R. H. Painter, indicating that this species must be widely distributed in Mexico. I have seen one specimen of the subgenus *Arachnospila* from a locality deep in Mexico, but have been unable to identify the species with certainty. *Pompilus apicatus* Provancher, a member of the subgenus

[1]Evans, H. E., 1951, Trans. Amer. Ent. Soc., 77: 203–275.

[2]This collecting trip was made possible to the author by a grant-in-aid from the Penrose Fund of the American Philosophical Society.

Anoplochares, is recorded from Brownsville, Texas, and probably occurs in parts of northern Mexico.

KEY TO SUBGENERA OF POMPILUS

Females

1. Ultimate tarsal segments either without spines beneath, or with from one to three spines near the base, and apical half bare; posterior margin of pronotum arcuate or obtusely angulate 1
   Ultimate tarsal segments with a more or less complete row of spines beneath, like the preceding segments; posterior margin of pronotum usually rather sharply angulate 5
2. Tarsal comb absent; spatium frontale elevated, the front abruptly declivous between the antennal sockets to the lower plane of the area frontalis. ..... **Xenopompilus** new subgenus
   Tarsal comb present; spatium frontale not prominently elevated as above... 3
3. Front basitarsus with only two comb-spines; third submarginal cell only a small fraction of the size of the second, or actually absent ..... **Perissopompilus** Evans
   Front basitarsus with three or four comb-spines; third submarginal cell at least half as large in area as the second 4
4. Ultimate tarsal segments without spines beneath; propodeum and mesopleura bare or with dark hairs; pulvillar comb weak. . **Hesperopompilus** Evans
   Ultimate tarsal segments with from one to three spines beneath near the base; propodeum, mesopleura, temples, and front coxae with abundant white hair; pulvillar comb strong ..... **Xerochares** Evans
5. Tarsal comb absent; labrum partially exserted ..... **Anoplochares** Banks
   Tarsal comb present; labrum mostly concealed by the clypeus 6
6. Marginal cell of fore wing 1.3 or more times its own length from the wing-tip. ..... **Ammosphex** Wilcke
   Marginal cell of fore wing approximately its own length from the wing-tip. ..... **Arachnospila** Kincaid

Males

1. Ultimate segment of front tarsus slender, symmetrical or nearly so, at most very obscurely produced on the inner margin 2
   Ultimate segment of front tarsus broader, distinctly produced along the inner margin, asymmetrical 5
2. Apical margin of clypeus rounded; subgenital plate with basal (internal) appendages consisting of matted setae ..... **Hesperopompilus** Evans
   Apical margin of clypeus truncate; subgenital plate without appendages of this kind 3
3. Postnotum on the median line much shorter than the metanotum; propodeum and mesopleura with abundant long, whitish hairs ..... **Xerochares** Evans
   Postnotum on the median line about as long as the metanotum; propodeum and mesopleura without long white hairs, the propodeum, however, with suberect silvery setulae 4
4. Pubescence of the abdomen forming dense, prominent bands at the apices of the tergites; sixth sternite with a specialized median area; basal hooklets of genitalia double ..... **Perissopompilus** Evans
   Pubescence of abdomen uniformly silvery, not forming bands; sixth sternite not modified; basal hooklets absent (fig. 1) ..... **Xenopompilus** new subgenus
5. Ultimate segment of front tarsus very strongly lobed along the inner margin, the segment widest about mid-way; aedoeagus with tooth-like projections along the margins ..... **Ammosphex** Wilcke
   Ultimate segment of front tarsus less strongly lobed, the segment widest about two-thirds the distance from the base; aedoeagus simple 6
6. Labrum partially exserted; subgenital plate very narrow, strongly keeled. ..... **Anoplochares** Banks
   Labrum not or scarcely visible beyond the apical margin of the clypeus; subgenital plate broader than above, keeled or not ..... **Arachnospila** Kincaid

Subgenus **Perissopompilus** Evans

Pompilus (Perissopompilus) phoenix Evans

1948, Pan-Pac. Ent., 24: 123; 1951, Trans. Amer. Ent. Soc., 77: 223.

This very distinctive species was previously recorded from Mexico, but without definite locality data. It was collected during the summer of 1951 at moderate altitudes in three states of south-central Mexico, and it is probably safe to assume that it occurs throughout the Nearctic parts of Mexico.

Distribution records are as follows: HIDALGO: 1 ♀, Zimapán, 11–14 June, 1951, on *Condalia mexicana* Schl. (Evans). MEXICO: 3 ♀♀, Teotihuacán Pyramids, 16 June, 7 July, 1951 (Hurd & Evans). PUEBLA: 1 ♀, 3 ♂♂, Tehuacán, on honeydew, 23 June, 1951 (Evans). United States records include the states of Texas, Arizona, Utah, and California.

Pompilus (Perissopompilus) perfasciatus Evans

1951, Trans. Amer. Ent. Soc., 77: 225.

This anomalous species was described from a single specimen from Whitewater, Riverside Co., Calif. It is not known from Mexico, though it doubtless occurs in the northwest part. I take this opportunity to record a second specimen of this species, a female taken at Indio, Riverside Co., Calif., by Dr. Paul Hurd on April 5, 1951.

Xenopompilus new subgenus

Genotype: *Pompilus* (*Xenopompilus*) *tlahuicanus* new species.

This subgenus resembles *Hesperopompilus* and *Perissopompilus* in the wide postnotum, the bristling silvery pubescence on the male propodeum, and the shape of the pronotum (characters which all of these groups share with the genus *Agenioideus*). *Xenopompilus* resembles *Hesperopompilus* in the bluish vestiture and in the complete absence of spines beneath the apical tarsal segments. The transverse rugae on the propodeum of some females and the absence of a tarsal comb are characters suggesting a relationship with *Agenioideus* and its various subgenera. The genitalia, though not dissimilar to those of certain species of *Hesperopompilus*, such as *boharti*, are surprisingly similar to those of some Aporini; the female of one species of *Xenopompilus* actually has somewhat incrassate front femora, again suggesting some of the Aporini. In the hind wing the anal vein runs parallel to the preaxillary furrow for some distance before arching off to join the media, thus approaching the presumably primitive condition found in *Allaporus* and in *Tastiotenia*. Unique features include the slightly setose antennal flagellum of the female and the prominent spatium frontale. All in all, this subgenus presents a most interesting mixture of characteristics. Since only one male is known, some modification of the male characters given in the following diagnosis may eventually become necessary.

Subgeneric characters.—Small wasps, 6.5 to 12 mm. in length; color black, the apical tergite of the male with a white spot. Vestiture of the female conspicuously bluish, that of the male somewhat so, but mostly silvery; pubescence of the male propodeum suberect, bristling,

silvery. Front and vertex with numerous short dark setae; thorax and propodeum either scarcely hairy or with scattered short, dark setae; abdomen slightly setose apically. Antennal flagellum of female bearing scattered short, suberect setae.

Apical margin of clypeus truncate or very slightly concave. Malar space short or practically absent. Front, in both sexes, rather prominent above the antennal sockets, sloping steeply between the sockets, the spatium frontale thus on a higher plane than the area frontalis. Vertex not elevated above the eye-tops; temples not strongly developed. Postocellar line, in all known species, greater than the ocello-ocular line. Posterior pronotal margin obtusely angulate; median line of pronotum faintly impressed in the female. Scutellum very prominent; postnotum broadened medially, in the male as broad medially as the metanotum. Propodeum with the declivity not prominent; slope with transverse rugae in some species. Mesosternum somewhat produced over the inner bases of the middle coxae. Legs rather weakly spinose, the front tarsus with no trace of a comb. Ultimate tarsal segments not spined beneath. Pulvillar pad small, the comb weakly developed. Ultimate segment of front tarsus of male nearly symmetrical, only very obscurely produced on the inner margin; inner claw of front tarsus of male curved rather strongly, bifid, the outer claw a little more curved than those of the remaining tarsi, sub-bifid; claws of remaining legs toothed.

Hind wing with the anal vein paralleling the preaxillary furrow for most of its length, then arching off to join the media considerably before the origin of the cubitus. Fore wing with the basal and transverse median veins interstitial or the latter meeting the media apicad of the former. Marginal cell removed from the wing-tip by more than its own length; radial vein somewhat angled at the third transverse cubital vein. Third submarginal cell narrowed above; second submarginal cell trapezoidal, considerably wider than high. Second recurrent vein arising on the subdiscoidal vein approximately half-way between the base of the subdiscoidal vein and the outer wing margin.

Sixth abdominal sternite of the male unmodified except for a large, U-shaped apical emargination. Subgenital plate of simple structure, the sides tapering gradually to a narrowly rounded apex; median line not much elevated; plate without conspicuous setae. Genitalia (fig. 1) of unusual structure: aedoeagus slender, exceeding the other appendages, the extreme apex very thin, hyaline, the gonopore located about midway on the shaft; parapenials strong, the inner margin acutely produced opposite the gonopore; basal hooklets wanting; parameres

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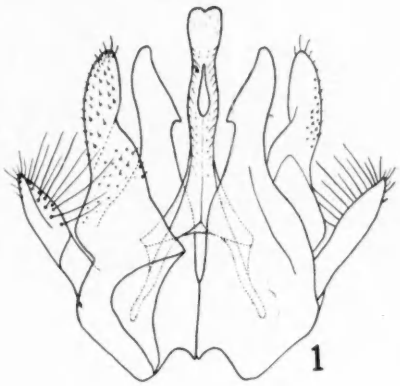
EXPLANATION OF FIGURES

FIG. 1. Male genitalia of *Pompilus* (*Xenopompilus*) *tlahuicanus* n. sp., ventral aspect on left side, dorsal on right. FIG. 2. *P.* (*Ammosphex*) *solonus teotihuacanus* n. subsp., ventral aspect of left paramere and volsella. FIG. 3. *P.* (*Ammosphex*) *parvulus tepahuanus* n. subsp., ventral aspect of left paramere and volsella. FIG. 4. Same, subgenital plate. FIG. 5. *P.* (*A.*) *anomalus durangoanus* n. subsp., ventral aspect of left paramere and volsella. FIG. 6. *P.* (*A.*) *parvulus otomi* n. subsp., ventral aspect of left paramere and volsella. FIG. 7. Same, subgenital plate. FIG. 8. *P.* (*A.*) *angularis volcanicus* n. subsp., ventral aspect of left paramere and volsella.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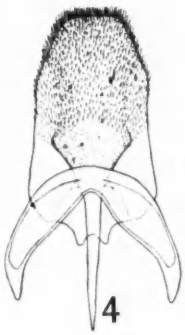
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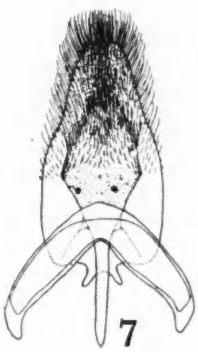
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unusually short, provided with a number of long setae which are directed mesad.

KEY TO FEMALES[3]

1. Front femora slightly incrassate, their length about three times their greatest width; labrum well exserted beyond the apical margin of the clypeus; antennae short, the third segment equal to only about 0.6 the upper interocular distance..... **tarascanus** new species
   Front femora slender, their length nearly four times their maximum width; labrum not exserted beyond the margin of the clypeus; third antennal segment equal to at least 0.7 the upper interocular distance..... 2
2. Propodeum with rather prominent transverse rugae; postnotum finely granulose, with some faint striations anteriorly; antennae slightly shorter, the third segment barely longer than the fourth..... **tlahuicanus** new species
   Propodeum with very faint rugae; postnotum with some rather strong, irregular rugae anteriorly; antennae slightly longer, the third segment notably longer than the fourth..... **tarahumarae** new species

Pompilus (Xenopompilus) tlahuicanus new species

The female of this species may be identified by the characters presented in the key. This is the only species of the subgenus in which the male is at present known. It is named for the Tlahuica, a tribe of Aztecs which formerly lived in the state of Morelos, Mexico.

Female.—Length 9 mm.; fore wing 7.5 mm. Color of integument black; body rendered by the pubescence a brilliant metallic Prussian blue. Fore wings moderately infuscated, strongly reflecting bluish; hind wings nearly hyaline, the outer margin infuscated. Scape and flagellum sparsely short-setose; clypeus, front, and vertex with short dark setae; temples with short setae, propleura with somewhat longer ones; front coxae, pronotum, mesonotum, and scutellum each with a very few erect setae; propodeum, pleurites, and middle and hind coxae without erect setae.

Labrum scarcely evident beyond the apical margin of the clypeus; clypeus 2.7 times as broad as high, its apical margin with a narrowly elevated rim. Front rather narrow, the middle interocular distance 0.54 times the transfacial distance; inner orbits nearly parallel, the upper interocular distance 0.9 the lower interocular distance. Postocellar line: ocello-ocular line as 4 : 3; ocelli in about a right triangle. Malar space practically absent. First four antennal segments in a ratio of about 20 : 6 : 22 : 21, segment three nearly four times as long as thick, equal to 0.75 times the upper interocular distance. Postnotum and propodeum with the median line strongly impressed; postnotum finely granulose, with some faint striations anteriorly. Propodeum with fairly prominent transverse ridges, most noticeable on the sides of the declivity. Front femora slender, 3.7 times as long as their greatest thickness. Fore wing with the marginal cell 2.7 times as long as high, removed from the apex of the wing by 1.5 times its own length. Third transverse cubital vein strongly arched; third submarginal cell subtriangular, narrowed by 0.8 above; second submarginal cell 1.3 times as long as high.

A single female paratype is very similar to the type; the third

[3]The male of only one species, *tlahuicanus*, is known.

antennal segment is 0.72 times the upper interocular distance; the third submarginal cell is triangular.

Male.—Length 7 mm.; fore wing 6 mm. Body black; apical abdominal tergite with a large white spot. Pubescence silvery over most of the body, somewhat cinereous on the outer parts of the legs, reflecting a little bluish on parts of the thorax and abdomen; pubescence generally very fine, but more coarse on the temples, hind coxae, and propodeal declivity, on the latter somewhat erect. Wings hyaline, the outer margins of the fore wings narrowly infuscated. Scape, clypeus, front, and vertex with numerous short dark setae; pronotum, mesonotum, and scutellum each with a few small setae; body otherwise without erect hairs.

Clypeus about twice as broad as high, its apical margin straight. Front rather narrow, the middle interocular distance 0.6 the transfacial distance. Inner orbits diverging above, the upper interocular distance 1.2 times the lower interocular. Postocellar line: ocello-ocular line as 5 : 3; angle formed by the ocelli in front much greater than a right angle. First four antennal segments in a ratio of about 24 : 10 : 18 : 19, the third segment about 1.5 times as long as its greatest thickness. Posterior pronotal margin broadly arched, more or less angled medially. Postnotum medially as long as the metanotum, bearing feeble and irregular transverse rugae. Median line of propodeum impressed in front; slope of propodeum low and even. Legs slender; middle and hind tibiae with numerous moderately long spines; longer spur of hind tibiae 0.8 the length of the basitarsus. Wing venation as described under the female; third submarginal cell short-petiolate. Abdomen slender; terminalia as described under the subgeneric heading; genitalia shown in figure 1.

Holotype.—MORELOS: Female, Alpuyeca, 27 June 1951 (Hurd). *Allotype.*—Male, same data as type. [Univ. Calif.] *Paratype.*—Female, Cuernavaca, 26 June 1951 (Evans) [U. S. Nat. Mus.]

Pompilus (Xenopompilus) tarahumarae new species

Named for the Tarahumara Indians of Chihuahua, this species is very similar to the preceding, from which it may be separated by the characters indicated in the key.

Female.—Length 12 mm.; fore wing 10 mm. Color of integument black; pubescence conspicuously bluish over the entire body, except the legs, where it is somewhat cinereous. Fore wings moderately infuscated, darker along the outer margin, strongly reflecting bluish; hind wings lightly infuscated, darker apically. Scape and flagellum sparsely short-setose; clypeus, front, vertex, temples, and propleura with short dark erect hairs; front coxae, pronotum, mesonotum, and scutellum with sparse small setae; body otherwise without erect hairs except for a few at the apex of the abdomen.

Clypeus 2.7 times as broad as high, its apical margin with a narrowly elevated rim. Middle interocular distance 0.56 times the transfacial distance; upper interocular distance 0.85 times the lower interocular distance. Postocellar line: ocello-ocular line as 5 : 4; ocelli forming an angle in front which is slightly greater than a right angle. First four antennal segments in a ratio of about 25 : 8 : 29 : 25, the third

segment about four times as long as thick, equal to 0.8 the upper interocular distance. Postnotum impressed medially, with some strong and rather irregular rugae toward the anterior margin. Propodeum with the median line strongly impressed in front; declivity nearly flat, the sides of the declivity with very faintly indicated transverse rugae. Front femora slender, about 3.8 times as long as their greatest thickness. Marginal cell of the fore wing about 1.5 times its own length from the wing-tip. Third submarginal cell narrowed by 0.7 above; second submarginal cell trapezoidal, a little wider than high.

A single female paratype is 9 mm. long, the fore wing 7.5 mm. long. The third submarginal cell is narrowed by only half above. Otherwise it closely resembles the type.

Holotype.—DURANGO: Female, 10 km. no. of Nombre de Dios, 5 Aug. 1951, on *Baccharis* (Evans). [U. S. Nat. Mus.]. *Paratype*—CHIHUAHUA: Female, 25 km. So. of Chihuahua, 11 Aug. 1951, on *Baccharis* (Evans) [Coll. author].

Pompilus (Xenopompilus) tarascanus new species

This species possess a number of unusual morphological features. From the exserted labrum, slightly swollen front femora, slightly compressed apex of the abdomen, and relatively smooth legs, I would assume (by analogy with other forms) that this species enters the nests of certain spiders, probably in the ground, and leaves the paralyzed spider in its own nest. It is named for the Tarascan Indians of Michoacan.

Female.—Length 8 mm.; fore wing 7 mm. Color of integument black; pubescence rather strongly reflecting bluish over the entire body. Fore wings moderately infuscated, violaceous; hind wings lightly infuscated, darker apically. Scape and flagellum sparsely short-setose; clypeus, front, vertex, temples, and propleura with rather abundant short dark hairs; pronotum, mesonotum, scutellum, propodeum, mesopleura, and coxae all with sparse short erect setae; abdomen slightly setose ventrally and at the apex above and below.

Labrum well exserted beyond the apical margin of the clypeus, truncate apically. Apical margin of clypeus nearly straight, without an elevated rim; clypeus 2.2 times as broad as high. Malar space fairly well developed, half the length of the antennal pedicel. Middle interocular distance 0.56 times the transfacial distance. Front very prominent above the antennal sockets, where there is a slight median impression; inner orbits nearly parallel, the upper interocular distance 0.95 times the lower. Postocellar line: ocello-ocular line as 4 : 3, the ocelli in about a right triangle. First four antennal segments in a ratio of about 19 : 5 : 17 : 17, segment three about three times as long as thick, equal to 0.63 times the upper interocular distance.

Postnotum depressed medially, anteriorly with some small striations extending laterally from the median line. Propodeum with the median line impressed in front; declivity oblique, nearly flat; no evidence of transverse rugae. Front femora slightly incrassate, about three times as long as their maximum width. Marginal cell of the fore wing about 2.5 times as long as high, removed from the wing-tip by 1.3 times its own length. Third submarginal cell subtriangular, narrowed by 0.8 above; second submarginal cell slightly wider than high.

A single female paratype is smaller, being only 6.5 mm. long, the fore wing 6 mm. The middle interocular distance measures 0.63 times the transfacial distance; the third antennal segment is equal to 0.58 times the upper interocular distance.

Holotype.—MICHOACAN: Female, 5 km. W. of Zacapu, 13 July 1951 (Hurd) [Univ. Calif.]. *Paratype.*—MEXICO: Female, Teotihuacán Pyramids, 15 June 1951 (Evans) [U. S. Nat. Mus.].

Subgenus **Ammosphex** Wilcke

Only one specimen of this subgenus, a female from Baja California tentatively assigned to *anomalus*, was known to me during preparation of my study of the Nearctic Pompilini. It was with some surprise that I found members of this subgenus to be widely distributed at higher altitudes in many parts of Mexico. All of the Nearctic species except *luctuosus*, *imbecillus*, and *michiganensis* were taken. The females taken are, for the most part, indistinguishable from their counterparts in the United States. However, in several cases the males appear to show constant differences in details of the terminalia. These differences are sometimes fairly prominent, though no other characters of the body appear to be effected. Apparently segments of populations of several species of *Ammosphex* have been sufficiently isolated in certain parts of the Mexican highlands to diverge structurally to the extent that they now form discrete subspecies.

Since the species occurring in Mexico all occur in the United States, and since the Mexican subspecies differ only in characters of the male, I have not presented a key to females in the present paper. The key to females in my study of the U. S. species will serve well enough for this purpose. I pointed out in that paper the great difficulty in separating females of the *angularis* complex. All three species of this complex occur widely in Mexico, frequently flying together in the same habitat. Unfortunately I am still unable to present characters which will separate the females of this complex with any degree of certainty. The following key will separate males of the species and subspecies of *Ammosphex* known to occur in Mexico; it also includes the U. S. subspecies in order to indicate their differences from the Mexican forms. Figures of the genitalia and subgenital plates of the U. S. subspecies will be found in my revisionary study of those forms.

KEY TO MALES

1. Subgenital plate with a pencil or tuft of erect hairs on the median line subapically; margins of aedoeagus not strongly sinuate (*Luctuosus*-group) 2

   Subgenital plate without a distinct pencil or tuft of long erect hairs subapically, the plate occasionally roughly setose over much of its surface; margins of the aedoeagus sinuate in such a manner as to delimit three lobes along the shaft (*Angularis*-group) 5

2. Subgenital plate with a long pencil of setae just before the apex, the plate otherwise nearly flat and devoid of setae; outer two-thirds of the aedoeagus with denticles along the margins ..... **occidentalis** (Dreisbach)

   Subgenital plate with a short tuft of setae subapically, the plate more or less elevated medially and with short setae on the disc or median ridge; aedoeagus with marginal denticles only on the apical third 3

3. Subgenital plate with less prominent setae, these mostly confined to the median line, the plate more or less broadly rounded apically; parameres much broadened apically; Texas, New Mexico, and Colorado ..... **solonus silvivagus** Evans

Subgenital plate with prominent suberect setae on and along the sides of the median line; sides of the plate tapering to a narrowly rounded or somewhat acute apex; parameres more slender apically..... 4

4. Entire disc of subgenital plate somewhat elevated; parameres slightly expanded apically; Arizona, Utah, and California..**solonus solonus** (Banks)
Subgenital plate strongly elevated along the median line; parameres slender, linear (fig. 2); Mexican states of Mexico and Zacatecas.....
.....**solonus teotihuacanus** new subspecies

5. Subgenital plate with the sides tapering evenly to a subacute apex, with only fine pubescence on the disc; parameres with abundant long, bushy hairs apically..... 6
Subgenital plate broader or with the sides not tapering evenly as above; parameres with less abundant hairs apically..... 7

6. Parameres slender and attenuate apically, much exceeding the digiti; transcontinental in the United States.....**angularis angularis** (Banks)
Parameres broad and blunt apically (fig. 8), only slightly exceeding the digiti; known from the Mexican states of Durango and Mexico.....
.....**angularis volcanicus** new subspecies

7. Subgenital plate slender apically, the margins flared out and roughly pubescent toward the base; digiti more narrow apically, the disc clothed with moderately prominent setulae..... 8
Subgenital plate relatively broad apically, the margins not flared out toward the base as above; digiti broader apically, the setulae on the disc very minute..... 9

8. Setulae on the sides of the base of the parameres prominent, bristling; western U. S. and Canada.....**anomalus anomalus** (Dreisbach)
Setulae on the sides of the base of the parameres small, much less prominently bristling (fig. 5); known from Durango, Mexico.....
.....**anomalus durangoanus** new subspecies

9. Subgenital plate with moderately long setae along the margin and over most of the disc, especially along the median line (fig. 7); parameres with numerous long setae apically; known from Hidalgo, Puebla, Mexico, and Morelos.....**parvulus otomi** new subspecies
Subgenital plate with only fine pubescence; parameres with fewer and smaller setae apically.....10

10. Parameres very slender and weakly setose (fig. 3); subgenital plate broad, more or less truncate apically (fig. 4); Durango.....
.....**parvulus tepahuanus** new subspecies
Parameres broader and rather strongly setose; subgenital plate somewhat more slender, especially apically; western U. S. and Canada.....
.....**parvulus parvulus** (Banks)

Pompilus (**Ammosphes**) **occidentalis** (Dreisbach)

1951, Amer. Midl. Nat., 42: 726. Evans, 1951, Trans. Amer. Ent. Soc., 77: 253.

Specimens of this species from two localities deep in Mexico differ from U. S. specimens only in the somewhat smaller average size and the somewhat more intensely bluish integument. There appear to be no structural differences in the terminalia or elsewhere. The typical habitat of the species is open spots in humid high-altitude forests.

Mexican records are as follows: PUEBLA: 1 female, 14 mi. W. of Huauchinango, in pine forest at about 7000 feet elevation, 16 June 1951 (Evans); MEXICO: 6 females, 3 males, West slope of Popocatépetl, in evergreen forest at about 9600 feet elevation, 5 July 1951 (Evans & Hurd).

Pompilus (**Ammosphex**) **solonus teotihuacanus** new subspecies

This is one of the most distinctive species of this subgenus, and is easily recognized in both sexes. Specimens taken in the southern parts of the Mexican central plateau appear to resemble typical *solonus*

more than its more eastern subspecies *silvivagus*. The males, however, show constant differences in the subgenital plate and genitalia from both of these subspecies.

Female.—Length 12 mm.; fore wing 9.5 mm. Color black; pubescence dark, nowhere silvery, over much of the body reflecting deep blue-green; fore wings moderately infuscated, with a darker marginal band, violaceous; hind wings lightly infuscated, darker apically. Scape hairy beneath; clypeus, front, and vertex moderately hairy; thoracic dorsum and sides of the propodeum with sparse setae; front coxae and to a lesser extent the front femora somewhat setose. Middle interocular distance 0.54 times the transfacial distance. First four antennal segments in a ratio of about 6 : 2 : 10 : 9, segment three equal to 0.85 times the upper interocular distance. Postocellar line: ocello-ocular line as 5 : 4. Comb-spines of front tarsus about twice as long as the thickness of the tarsus. Marginal cell of the fore wing about twice its own length from the wing-tip; third submarginal cell a little wider than the second both above and below.

A single female paratype is 9.5 mm. long; the third antennal segment is equal to 0.9 the upper interocular distance. In other respects it is very similar to the allotype described above.

Male.—Length 8 mm.; fore wing 7 mm. Color black; pubescence reflecting deep blue-green, except silvery as follows: clypeus, scape beneath, front, temples, all the coxae, to some extent the pronotum, mesopleura, and propodeum, metanotum, sides of the scutellum, and bases of the first two abdominal tergites. Wings nearly hyaline, with a brownish marginal band. Scape hairy below; clypeus, front, vertex, temples, and propleura prominently hairy; pronotum, scutellum, and propodeum very sparsely setose. Middle interocular distance 0.55 times the transfacial; upper and lower interocular distances about equal. First four antennal segments in a ratio of about 2 : 1 : 2 : 2, segment three somewhat over twice as long as thick. Ocelli about as in the female.

Abdominal sternite six with a broadly U-shaped emargination. Subgenital plate with the sides tapering to a narrowly rounded apex; median line forming a broadly elevated ridge; disc with erect, bristling setae along and on the sides of the median elevation; the elevation breaks off suddenly just before the apex, and at this point is a tuft of somewhat longer setae, about as long as the distance from their base to the apex of the plate; apex also with a few setae. In its general shape and in the nature and abundance of setae, the subgenital plate resembles that of *solonus solonus;* the elevated median ridge is, however, similar to that of subspecies *silvivagus*. Genitalia closely resembling those of the other subspecies except for the parameres, which are unusually slender, linear, slightly curved subapically, and clothed apically with sparse, long setae (fig. 2); the parapenials are stout, somewhat truncate apically.

Four male paratypes vary greatly in size, from 5 to 10 mm.; some specimens are more extensively silvery-sericeous than the type; in two specimens the front is considerably broader than in the type.

Holotype.—MEXICO: Male, Teotihuacán Pyramids, 6 July 1951, on leguminous shrubs exuding honeydew (Evans). *Allotype.*—Female,

same data as type. [U. S. National Museum.] *Paratypes*—1 female, 2 males, same data as type but dated 15 June, 6 July, and 7 July 1951 (Hurd & Evans); ZACATECAS: 2 males, 15 km. E. of Sombrerete, about 7000 feet, 28–31 July 1951 (Hurd & Evans).

Pompilus (Ammosphex) angularis volcanicus new species

In central Mexico, *angularis* is to be found at higher altitudes and in more forested areas than *solonus*. One pair was taken at over 11,000 feet on the volcano of Toluca. The male taken here, and three males taken near El Salto, Durango, all have the parameres of the genitalia much shorter and more truncate than in typical *angularis*. The females are not, however, clearly distinguishable from *angularis angularis;* they appear to differ from *parvulus* and *anomalus* and their subspecies in having the third antennal segment notably shorter than the first two together, and equal to not more than two-thirds the upper interocular distance.

Female.—Length 6 mm.; fore wing 5 mm. Color black; pubescence wholly dark, obscurely violaceous; wings lightly infuscated, the fore wings with a darker marginal band, slightly violaceous. Body without erect setae except for a few on the head, prothorax, scutellum, and apex of the abdomen. Middle interocular distance 0.58 times the transfacial distance; upper interocular distance 0.8 the lower interocular distance. First four antennal segments in a ratio of about 7 : 3 : 9 : 8, segment three equal to 0.67 times the upper interocular distance. Postocellar and ocello-ocular lines equal. Comb-spines of the front tarsus about as long as the thickness of the tarsus. Marginal cell of fore wing 2.7 times its own length from the wing-tip; second and third submarginal cells both much narrowed above; third discoidal cell 1.8 times as broad as high.

Four female paratypes vary in length from 5 to 6 mm. All possess a patch of silvery pubescence at the sides of the antennal sockets. Otherwise they closely resemble the allotype described above.

Male.—Length 6 mm.; fore wing 5 mm. Color black; wings nearly hyaline, the broad outer margin of the fore wing and tip of the hind wing infuscated. Head and thorax extensively silvery-sericeous, the abdomen slightly so at the base. Middle interocular distance 0.59 times the transfacial distance; upper and lower interocular distances equal. First four antennal segments in a ratio of about 19 : 6 : 16 : 19, segment three slightly over twice as long as thick. Marginal cell of fore wing three times its own length from the wing-tip. Abdominal sternite six with a large V-shaped emargination. Subgenital plate entirely covered with small setulae, its margins tapering evenly to a narrowly rounded apex. Genitalia with the slender, somewhat pointed aedoeagus characteristic of the species; disc of digiti evenly clothed with small setae; parameres slightly longer than the digiti, broad, rather blunt apically, and clothed on the outer third with long, bushy setae (fig. 8).

Three male paratypes vary in length from 4.5 to 6 mm.; they differ from the type only in minor details.

Holotype.—MEXICO: Male, Volcano of Toluca, about 11,300 feet elevation, on ground in open pine forest, 11 July 1951 (Hurd). *Allo-*

type.—Female, same data as type [Univ. Calif.]. *Paratypes*.—DURANGO: 4 females, 3 males, El Salto, about 8000 feet, on ground in pine-oak forest, 3 Aug. 1951 (Hurd & Evans).

Pompilus (Ammosphex) anomalus durangoanus new subspecies

A series of *anomalus* taken at El Salto, Durango, flying with *angularis volcanicus* and *parvulus tepahuanus*, appears to show minor but constant differences in the male genitalia from specimens from the United States. Females which probably belong here have the third antennal segment subequal to the first two together, and equal to about three-fourths the upper interocular distance.

Female.—Length 6 mm.; fore wing 5 mm. Color black; pubescence fusco-violaceous, on the sides of the lower front and clypeus conspicuously silvery; wings strongly violaceous. Middle interocular distance 0.57 times the transfacial distance; upper interocular distance 0.83 times the lower interocular distance. First four antennal segments in a ratio of about 11 : 4 : 15 : 14, segment three thus about equal to the first two together, and this segment equal to 0.73 times the upper interocular distance. Postocellar and ocello-ocular distances equal. Median line of propodeum lightly impressed. Comb-spines of front tarsus about as long as the thickness of the tarsus. Marginal cell of fore wing three times its own length from the wing-tip; third discoidal cell 1.6 times as wide as high.

Male.—Length 5.5 mm.; fore wing 4.5 mm. Color black; wings nearly hyaline, the outer margin of the fore wing and apex of the hind wing broadly infuscated. Head, thorax, and base of the abdomen extensively silvery-sericeous. Middle interocular distance 0.58 times the transfacial distance; upper and lower interocular distances equal. First four antennal segments in a ratio of about 18 : 7 : 16 : 18, segment three slightly more than twice as long as thick. Marginal cell of fore wing 2.7 times its own length from the wing-tip; second and third submarginal cells both higher than wide, both much narrowed above; third discoidal cell 1.5 times as wide as high. Sixth abdominal sternite with a broad, U-shaped emargination. Subgenital plate as in typical *anomalus*, very slender apically, inwardly abruptly broadened, rather roughly pubescent at the sinuations of the margins. Genitalia with the aedoeagus of moderate breadth, rather broadly rounded apically; digiti evenly clothed apically with small setae; parameres about as long as the aedoeagus, clothed with short setae which are slightly longer apically; on the sides toward the base these setae are more or less perpendicular to the shaft, and somewhat bristling, but much shorter and less prominent than in the nominate subspecies (fig. 5).

Four male paratypes closely resemble the type. The subgenital plate exhibits some variation in shape, as is usual in this species, though it still remains the best identification feature.

Holotype.—DURANGO: Male, El Salto, about 8000 feet, on ground in pine-oak forest, 3 Aug. 1951 (Evans). *Allotype*.—Female, same data as type. [U. S. Nat. Mus.]. *Paratypes*.—1 female, 4 males, same data (Evans & Hurd).

Pompilus (Ammosphex) parvulus tepahuanus new subspecies

This is a rather distinctive form in the male sex, but probably should be regarded a subspecies of *parvulus*. A number of females considered to belong here have the front rather narrow, the middle interocular distance varying from 0.54 to 0.56 times the transfacial distance. This subspecies is named for the Tepahuana Indians of Durango.

Female.—Length 6 mm.; fore wing 5.5 mm. Color black; pubescence dark, somewhat violaceous, on the sides of the lower front somewhat silvery. Wings lightly infuscated, slightly violaceous, the outer margin of the fore wing and apex of the hind wing broadly darker. Middle interocular distance 0.56 times the transfacial distance; upper interocular distance 0.8 the lower. First four antennal segments in a ratio of about 13 : 4 : 17 : 16, segment three thus about equal to the first two together, and this segment equal to 0.74 times the upper interocular distance. Postocellar and ocello-ocular lines equal. Median line of propodeum impressed. Marginal cell of fore wing three times its own length from the wing-tip.

Eight female paratypes vary in length from 5 to 7 mm. The middle interocular distance varies from 0.54 to 0.56 times the transfacial distance; antennal segment three varies from 0.71 to 0.82 times the upper interocular distance.

Male.—Length 6.5 mm.; fore wing 4.5 mm. Color black; wings nearly hyaline, the apical fourth of the front wing much darker; pubescence silvery over much of the body. Front rather narrow, the middle interocular distance 0.56 times the transfacial; upper interocular distance 0.95 times the lower. First four antennal segments in a ratio of about 10 : 4 : 9 : 10, segment three somewhat over twice as long as thick. Marginal cell of the fore wing 2.5 times its own length from the wing-tip; second and third submarginal cells both higher than wide. Apical emargination of abdominal sternite six U-shaped. Subgenital plate (fig. 4) broad, the apex truncate, the lateral margins parallel on the basal two-thirds, obliquely convergent on the apical third. Genitalia with the aedoeagus rather broadly rounded apically; digiti broadly expanded apically and with minute setae on the disc; parameres slender and weakly setose, the apex with a few fairly prominent setae (fig. 3).

Three male paratypes vary in length from 5 to 6 mm. In two of the specimens the subgenital plate is more narrow than in the type, and more rounded apically.

Holotype.—DURANGO: Male, El Salto, about 8000 feet, on ground in open pine-oak forest, 3 Aug. 1951 (Hurd). *Allotype.*—Female, same data as type. [Univ. Calif.]. *Paratypes.*—4 females, 3 males, same data as type; ZACATECAS: 4 females, 15 km. E. of Sombrerete, about 7000 feet. 28–31 July 1951 (Evans & Hurd).

Pompilus (Ammosphex) parvulus otomi new subspecies

This is a very distinctive form by virtue of the coarsely setose male subgenital plate and the group of setae at the apex of the parameres. It appears to be a rather common form at high altitudes in the southern parts of the Mexican central plateau, and was the

only member of this species-group taken at each locality where it was collected. It is named for the Otomi Indians, a tribe of early migrants into the Valley of Mexico.

Female.—Length 7 mm.; fore wing 5 mm. Black, the upper outer orbits with a small pale spot. Fore wings moderately infuscated, darker apically, strongly violaceous; hind wings lightly infuscated, darker apically. Pubescence dark, somewhat violaceous, a bit silvery on the lower front, front coxae, and propodeum. Clypeus, front, vertex, temples, front coxae, and pronotum each with a few erect hairs. Middle interocular distance 0.59 times the transfacial distance; upper interocular distance 0.82 times the lower. Posterior ocelli equidistant from each other and from the eyes. First four antennal segments in a ratio of about 23 : 9 : 28 : 25, segment three equal to 0.65 times the upper interocular distance. Median line of propodeum lightly impressed.

Eighteen female paratypes vary in length from 4 to 7 mm. The middle interocular distance varies from 0.55 to 0.61 times the transfacial distance. The third antennal segment in some specimens is about equal to the first two combined. The silvery pubescence is variable in amount and may be lacking altogether.

Male.—Length 4.5 mm.; fore wing 4 mm. Black; body extensively clothed with a fine silvery pubescence; wings lightly infuscated, the apical third of the fore wings with a brownish band. Front, vertex, temples, and propleura with a few erect hairs, the body otherwise devoid of setae except for the subgenital plate, as described below. Middle interocular distance 0.57 times the transfacial distance. Postocellar and ocello-ocular lines about equal. First four antennal segments in a ratio of about 17 : 8 : 15 : 16, segment three slightly more than twice as long as thick. Fore wing with the marginal cell removed from the wing-tip by about three times its own length; third discoidal cell 1.5 times as long as high. Subgenital plate (fig. 7) tapered apically, the tip rounded, the median line slightly elevated; entire ventral surface clothed with fairly long, suberect setae, which tend to be concentrated along the median line. Genitalia similar to those of *parvulus parvulus:* digiti much expanded apically, clothed with minute setae; lower set of basal hooklets very prominent; parameres about the same as in the nominate subspecies except for the prominent setae on the upper, outer margin (fig. 6).

Twenty-four male paratypes vary in length from 3.5 to 6.5 mm. The subgenital plate in some specimens is a little more narrow apically than in the type.

Holotype.—HIDALGO: Male, Zimapán, 11–14 June 1951, on *Condalia mexicana* Schl. (Evans). *Allotype.*—Female, same data as type. [U. S. Nat. Mus.]. *Paratypes.*—7 females, 10 males, same data as type; PUEBLA: 4 females, 11 males, 14 mi. W. of Huauchinango, about 7000 feet, on ground in clearing in pine forest, 17 June 1951 (Hurd & Evans); MEXICO: 2 females, 1 male, slopes of Popocatépetl, about 9600 feet, on forest floor, 5 July 1951 (Evans); MORELOS: 5 females, 2 males, 15 km. N. of Cuernavaca, on forest floor, about 7500 feet, 4 July 1951 (Hurd & Evans).

A PORTABLE REFRIGERATING DEVICE FOR THE COLLECTION AND RAPID INACTIVATION OF SMALL BIOLOGICAL SPECIMENS[1]

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A procedure widely employed for the inactivation of insects and other small arthropods in biochemical or medical studies is carbon dioxide anesthesia, following collection by aspirator or net or by hand. Frequently this anesthesia is followed by storage under refrigeration, including freezing, until further study is desired. The possibility of extenuating, modifying effects of such cardon dioxide treatment upon the normal biochemistry of biological specimens, although not seriously questioned or tested by such workers previously, nevertheless remains a definite limitation on this procedure.

Since the author has been engaged in a series of studies of a quantitative nature on the enzyme systems of insects, possible alterations in the normal activity of such systems by carbon dioxide pretreatment have been obviated by decapitation followed by rapid freezing (1) or by direct freezing of hand-collected or aspirated specimens (1, 2, 3). In the application of the last-mentioned procedure to biochemical studies in the common house fly (*Musca domestica*), it was observed that the animals were considerably agitated following aspiration and prior to freezing. It was therefore considered highly desirable if not imperative to employ a collecting-inactivating procedure by which specimens so obtained would remain in as nearly normal a state as was technically feasible, in such studies especially where intermediary metabolic processes were involved.

The apparatus shown in Fig. 1 is a portable refrigerating device originally designed as a cooling jacket for the tube of an aspirator, such as is commonly employed for field and laboratory collection of small arthropods, especially insects. It consists of a hollow, cylindrical brass cooling jacket with a central opening for the aspirator tube, (resembling roughly an "angel-food" cake tin) with a non-corrosive friction cover. An outer wooden sleeve serves as an insulating jacket which maintains heat gain at a minimum and protects the operator from low temperature injury. The hollow brass jacket chamber is filled with water, covered with the (aluminum) cover and stored until needed in a freezer (at —25° C. or below). In actual use, the

[1]The author acknowledges the assistance of Mr. J. T. Guptill in the actual fabrication of the apparatus described. He also acknowledges the aid of Mr. S. T. Allured in the preparation of the line drawings.

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aspirator is slipped into the cold jacket and the specimens aspirated by mouth or line vacuum into the now cold central tube. As the specimens are aspirated into the cold chamber they are almost instantly inactivated and quickly frozen. The central tube of the aspirator can now be separated from the two bored stoppers and replaced with

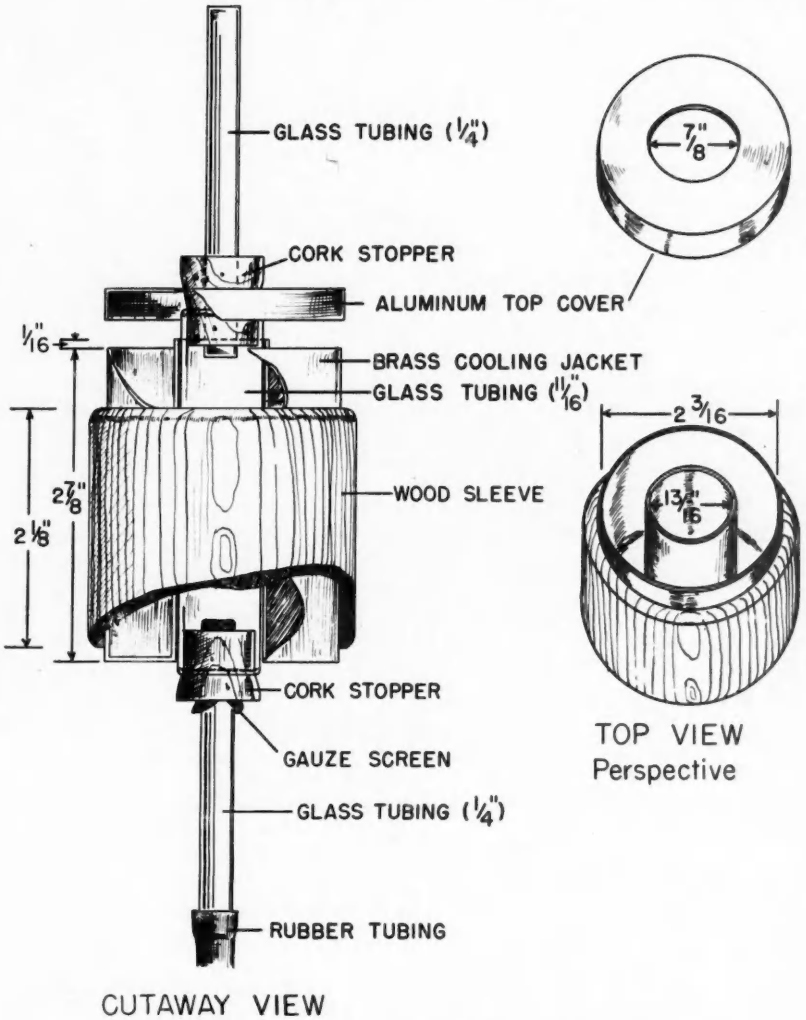

FIG. 1. Detail of the portable refrigerating apparatus.

solid cork stoppers; this can then be labeled and placed in the freezer for indefinite storage. It is useful to have a series of glass tubes with stoppers stored empty in the freezer and employed in connection with the aspirator as the need arises. Although the temperature of the

freezer drops slowly at room temperature and can be employed for about an hour at room temperature (20 to 25° C.) with continued freezing effectiveness, it will be found convenient to have an extra cooling jacket, especially in field collecting, so that the collector can alternate the use of one cooling jacket with the other which is being stored and kept cold in the freezer (or portable dry-ice box) when not in use.

By plugging one end of the central opening of the cooling jacket with a cork stopper of appropriate size, with a vial placed in this central opening (instead of the customary aspirator tube), this apparatus serves as a small refrigerating-freezing device, into which can be placed hand-collected specimens like mites, ticks, aphids, berries or seeds, for immediate inactivation and rapid freezing.

The dimensions given are purely arbitrary to suit the personal predilection of the author, but will be found to correspond closely to the general requirements of commonly-employed aspirators as well as to the hand size of the average collector. Its fabrication is relatively inexpensive (about $10 total cost at current prices) and simple for a local machine or instrument shop to effect. As a durable, simple and easily manipulated device, the apparatus described should lend itself to a variety of applications in the field or the laboratory, which may require rapid inactivation and freezing and indefinite storage of such material, where freezing does not affect the particular study or analysis involved.

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INSECTS CLOSE-UP, by EDWARD S. ROSS. Pp. 80. Published for the California Academy of Sciences by the University of California Press, Berkeley and Los Angeles. $1.50 in paper, $2.25 bound.

This is a beautifully prepared book of photographs, seven of them reproduced in color, with brief explanatory text and some drawings illustrating methods of collecting and preserving specimens. The subtitle, "A pictorial guide for the photographer and collector featuring 125 photographs and drawings," indicates the content. Data on equipment used for each photograph are included.

The patience of Dr. Ross is thoroughly attested by the photographs, most of them having living and active insects as subjects. The book will be interesting to children as well as adults, to photographers as well as entomologists and naturalists generally.

To research entomologists the book serves as a reminder of the value of photography as a tool to record insect attitudes, behavior, and structure.

CHARLES D. MICHENER.

INFLUENCE OF THE PROTEIN LEVEL OF THE DIET ON THE LONGEVITY OF COCKROACHES [1] [2]

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Diet has a great influence on the well being and longevity of animals. By restricting caloric intake McCay and co-workers (1935) brought about retardation of growth in young rats that resulted in increase in the total life span of these experimental animals. In a later paper, reporting the results of their study of the nutritional requirements during the later half of life, McCay and co-workers (1941), stated: "The optimal conditions for a long life (of rats) proved to be thin bodies, exercise and a low protein diet with the protein supplied by liver." Slonaker's (1935) experiments also indicated that the life span of both virgin and bachelor rats was shortest in the group which were fed higher (26%) protein diet. Unfortunately, he used a rather small number of animals in his assay experiments.

Northrop (1917) showed that if the larval period of *Drosophila* is prolonged by inadequate diet the total duration of life can be prolonged. Limitation of food during growth and development also increased the life span of *Daphnia* (Ingle and co-workers, 1937). Balduf (1941), in his quantitative dietary studies of *Phymata*, found that the average survival and rate of development of the nymphs and the average longevity, weight, size, mating activity and sexual productiveness of the resulting adults are directly proportional in most cases to the quantity and quality of food supplied. Noland and co-workers (1949) found that the growth response in *B. germanica* was greatest on a diet containing 30% casein. Decreased growth rates were observed with 45%, 20%, 15% and 10% of dietary casein. Later, however, Noland and Bauman (1951) established that a dietary level of 40% casein, in spite of variations in carbohydrates or roughage, appeared to be optimal for growth and maturation of the German cockroach (37 days to maturity). Other levels were effective in the decreasing order: 30% (40 days), 50% (44 days), and 15% (44 days). Sieburth and co-workers (1951) found that 25% casein best fulfilled the protein requirement for the American cockroach. Ten and 50% casein showed a sharply depressed rate.

METHODS

The present experiments were started in 1941. The cockroaches were obtained from the laboratory stock of an unknown origin. The diet on which these stock colonies had been reared consisted of whole

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TABLE I

INFLUENCE OF PROTEIN LEVEL OF DIET ON THE DEVELOPMENT AND LONGEVITY OF GERMAN COCKROACHES

ADULT FEMALES					ADULT MALES					DEVELOPMENT FROM HATCHING							
Protein level	Number of Insects	Food consumption per day per insect		Longevity	Protein level	Number of insects	Food consumption per day per insect		Longevity	Protein level	Number of nymphs	Number of adults	Mortality		Nymphal development	Adult life	Total life span
		Total	Protein				Total	Protein									
per cent	No.	mg.	mg.	days	per cent	No.	mg.	mg.	days	per cent			No.	per cent	days	days	days
11–24	27	1.7	.3	270	11–24	30	.8	.2	207	11	16	10	6	38	162	282	444
49–74	19	2.3	1.3	114	49	8	1.4	.7	123	22–24	34	30	4	12	115	223	338
79–91	21	1.4	1.2	74	74–79	18	1.2	.9	86	49	17	15	2	12	150	86	236
					86–91	15	1.3	1.2	68	74	16	10	6	38	136	78	213
										86–91	24	0	24	100	—	—	—

wheat flour 500 gm., dried brewers' yeast 100 gm., dried skim milk 200 gm., soybean flour 100 gm.; the total protein content of the ration being 26–27%. Individuals were removed to diets outlined below for the experiments summarized in this paper.

In the developmental studies the cockroaches were taken shortly after hatching and placed, in groups of about 10, in wide-mouthed pint jars or special cages with glass-lined walls, glass covers and elevated screen bottoms. The food was given in pop bottle caps from which the cork had been removed. In order to prevent the spilling of the food, a tin washer was placed on the surface of the food in the cap. Water was provided in glass vials plugged with cotton. In studying the nutrition of the adults, cockroaches were taken shortly after their last moult and both Oriental and American cockroaches were individually placed in isolated compartments, separated by a glass wall. The German males and females were kept in separate groups.

The experimental foods consisted of 10 gm. dried brewers' yeast, 4 gm. Hawk & Oser salt mixture, Labco vitamin-free casein and dextrin. The latter two ingredients were complemented so as to give rations containing 5, 11, 23, 49, 74 and 91% protein. Dried brewers' yeast was assumed to have 50% protein. Diets containing 22% and 86% protein had 20% dried brewers' yeast. Those with 24 and 79% had 10% dried egg yolk added. These changes have been made to ascertain whether the protein level of the diet has the same influence on the longevity of the cockroaches, regardless of the variations in other components of the diet. The diet containing 2.5% protein had only 5% yeast, the rest being salts and dextrin. Vitamins A, D and C were not supplied since, according to McKay (1938), there is no evidence that the German cockroach has any need for fat soluble vitamins A and D, and Wollman and co-workers (1937) concluded that the German cockroach can synthesize vitamin C. Caps with food were weighed and known amounts of food were added when necessary. Before weighing the cockroaches were anesthetized with ether. The insects were kept in the laboratory where temperatures ranged between 22° and 28° C. most of the time. On a few occasions the temperature reached 19° or 32° C. The results of the experiments are presented in Tables I, II and III.

RESULTS

From the tables it is evident that the protein level of the diet greatly influenced the longevity of the adults of all three species of roaches. The most favorable level for the German was between 11–24% and for the Oriental cockroaches was between 22–24%, while that for the Ameriean cockroaches was in a somewhat wider range. The amount of protein consumed daily seems to be inversely correlated with the longevity of the individual. The total daily food consumption does not seem to have such a correlation.

The lowest mortality and the shortest nymphal development in the German and Oriental cockroaches was on the diets containing 22–24% protein, while in the American roaches the range was higher, being 49–79%. Mortality and duration of the nymphal stadium increased on the diets of the lower and higher protein level. However,

TABLE II

INFLUENCE OF PROTEIN LEVEL OF DIET ON THE DEVELOPMENT AND LONGEVITY OF ORIENTAL COCKROACHES

ADULT FEMALES					ADULT MALES					DEVELOPMENT FROM HATCHING							
Protein level	Number of Insects	Food consumption per day per insect		Longevity	Protein level	Number of insects	Food consumption per day per insect		Longevity	Protein level	Number of nymphs	Number of adults	Mortality		Nymphal development	Adult life	Total life span
		Total	Protein				Total	Protein									
per cent		mg.	mg.	days	per cent		mg.	mg.	days	per cent			No.	per cent	days	days	days
22–24	21	10.5	2.4	185	0–11	15	4.2	.2	204	11	16	5	11	69	382	286	668
49	6	10.7	5.2	151	22–24	18	5.0	1.1	233	22–24	57	49	8	14	270	222	492
74–79	11	8.2	6.4	90	49	6	4.9	2.4	148	49	22	14	8	36	265	154	419
86–91	8	8.0	7.2	63	74–70	7	4.5	3.5	109	74–79	41	20	21	51	316	91	407
					86–91	6	4.3	3.7	56	86–91	34	5	29	85	325	33	358

the total life span of the experimental animals decreased with the increase of the protein level of the diet. This was due to the decreased longevity of the resulting adults which were fed a higher protein diet.

It should be pointed out that, while the average adult life span of the German cockroaches fed 22–24% protein level was about equal both for those fed diets containing yeasts (222 days) and those the diet of which was strengthened by an addition of dried egg yolk (225 days), the nymphal development was considerably shortened in the latter group (55 days) as compared with the former (133 days). The same phenomenon was not observed in the cases of the Oriental (268 and 274 days) and the American cockroaches (414 and 431 days, respectively). Nolan *et al.* (1949) in their study on vitamin requirements of roaches concluded that choline is required at a high level by the German roach. Probably the dietary requirements for growth are different for the German roaches from those for the Oriental and American cockroaches. However, the duration of life decreased with an increase in the protein level of the diet irrespective of the composition of the diet for all three species of cockroaches.

It is of interest to note that none of the German nymphs reached maturity on the diets containing 86–91% protein. Melampy and Maynard (1937) demonstrated that the German roach can develop on a high protein diet (100 gm. protein + 10 or 25 g. yeast) and that it is able to convert protein into body lipids. McCay (1938) came to the same conclusion. Gier (1947) found that the American roach on a pure protein diet lived only until the supply of fat stored in its fat bodies was exhausted. "They starved to death with plenty of proteins in their gut lumen and masses of crystals (of a protein nature) in their fat bodies." Sieburth and Bonsall (1951) also stated that American roaches reared at 50% level of casein showed sharply depressed growth rate. The results of the present study indicate that the German cockroach cannot develop on a high protein diet, while the American cockroaches tolerate the high protein diet considerably better than their German or Oriental counterparts. Thus, the results of the present study differ somewhat from the findings of the above mentioned authors.

A more extensive study was made on the American cockroaches. An autopsy was performed on each individual to establish the internal picture of the animals fed various diets. The cockroaches which were on the diets of pure dextrin or 2.5 and 5% protein had shrunken abdomens. There were no white deposits in coxae or in any other parts of the body. The fat body was practically absent. Internal organs seemed to be reduced in size. On 11% protein, deposits in the coxae and under the ventral integument were either none or very little. The fat body was meager or almost absent. On 22–24% protein, the abdomen was either shrunken, normal or somewhat distended. Deposits in the coxae were either none or slight, in the antennal socket, none, and in the neck—very little. The fat body was meager or normal. The lobules of the fat body were discernible. On 49% protein, the abdomen was swollen, distended, and white deposits were everywhere. The fat body was abundant, filling the whole body cavity. The lobules were still discernible. In a few cases internal organs were compressed. On 74% protein, the abdomen was distended and white

TABLE III

INFLUENCE OF PROTEIN LEVEL OF DIET ON THE DEVELOPMENT AND LONGEVITY OF AMERICAN COCKROACHES

ADULT FEMALES					ADULT MALES					DEVELOPMENT FROM HATCHING							
Protein level	Number of Insects	Food consumption per day per insect		Longevity	Protein level	Number of insects	Food consumption per day per insect		Longevity	Protein level	Number of nymphs	Number of adults	Mortality		Nymphal development	Adult life	Total life span
		Total	Protein				Total	Protein									
per cent		mg.	mg.	days	per cent		mg.	mg.	days	per cent			No.	per cent	days	days	days
0–5	13	6.8	.3	618	2.5–11	6	6.1	.5	791	11	16	4	12	75	787	604	1391
11–49	20	6.5	1.7	726	22–24	19	5.5	1.3	825	22–24	34	23	11	32	431	741	1172
74–79	20	7.6	5.9	613	49	5	5.4	2.6	790	49–79	51	41	10	20	366	643	1058
86–91	10	6.5	5.8	474	74–79	9	6.7	5.2	560	86–91	35	25	10	28	378	466	844
					86–91	11	6.1	5.4	516								

deposits were everywhere, including the antennal socket. The fat body completely filled the whole abdominal cavity, in many instances compressing the internal organs. On 79–86% protein, the same as above but more pronounced, and in a larger number of animals. On 91% protein, all abdomens were greatly distended and the fat body completely filled the whole abdominal cavity. There were visible white deposits in legs, head, and other parts with translucent integument. Internal organs were compressed. The white mass of the fat body hardened very quickly on exposure to the air. The impression was that the insects were choked by the accumulated mass of deposits. Qualitative tests made by Dr. A. G. Richards showed a very faint reaction for protein and fat, but a strongly positive murexide reaction which is thought to be indicative of the presence of uric acid. In this sense the term "uric acid" will be used in the present paper.

Similar distension of the abdomens and white deposits were visible under intersegmental membranes ventrally in Oriental and German cockroaches fed high protein diets. Gier (1947) noticed that upon death, the American roaches which had been fed high protein ration had "masses of crystals (of a protein nature) in their fat bodies." This is the only mention in the literature that the deposits of masses of crystals in the fat body of cockroach are of a protein nature. It is well known that the fat body of cockroaches contains substances which have been called urates and uric acid in entomological literature and that these substances increase with age. (Fabre '63, Patten '84, Faussek '11, Blochmann '87, Wheeler '89, Cuenot '95.)

The accumulation of uric acid in the fat body signifies that the insect could deaminize the proteins of the food. Consequently, they presumably use the proteins for energy. Whether the shortened life span on higher protein diets was due to a greater amount of waste materials accumulated in the fat body, thus actually choking the individual, or whether it was due to the inability of the insect to synthesize some necessary lipids, or whether death was due to some other causes—cannot be answered at the present.

The protein efficiency ratio (P.E. = grams of gain in body weight to grams of protein eaten) on various diets was also determined for the Oriental and the American cockroaches. The results are presented in Table IV.

From Table IV it is evident that P.E. ratio in general decreased with increase in the protein level of the diet and with increase in the age of the animal. This phenomenon was observed by Osborn, Mendel and Ferry (1919), the originators of this method for measuring the growth promoting value of proteins. From their table it is evident that there is an optimum percentage of protein in the diet, and, when that percentage was increased or decreased, the P.E. ratio diminished. It can be noticed, however, that the P.E. ratio is greater in the last measurement for the Oriental cockroaches. The cause of this is not known.

It is a known fact that the uric acid accumulated in the fat body can be transferred to other parts of an insect. (Hopkins, 1895, Wigglesworth, 1924 and 1942.) In order to find out whether the uric acid of the fat body of cockroaches can be disposed of by the animal, eight

adult cockroach paired brothers (from the same ootheca) were selected. At the beginning of this experiment the abdomens of all of these were greatly distended and typical white deposits were visible everywhere. Then one of each pair was left on the same diet, the other was given pure dextrin as food.

The results are presented in Table V. It is evident that at least most of the white deposits, presumably uric acid, in the adipose tissue of roaches raised on a high protein diet is removed from this tissue when the animal is transferred to a dextrin diet. Paralleling the loss of these visible deposits there is a weight loss of 7–23%. It is of interest to note that the food consumption of each member of a pair was about the same but that weight continued to be gained on the high protein diet whereas it was lost on the dextrin diet. Osborn and Mendel (Taken from Boas Fixen, 1935) demonstrated that rats

TABLE IV

PROTEIN EFFICIENCY OF THE DIETS IN SUCCESSIVE PERIODS OF GROWTH OF AMERICAN AND ORIENTAL ROACHES

Prot. Level per cent	AMERICAN				ORIENTAL					American Exploratory	Oriental Exploratory
	No. of nymphs	Periods			No. of nymphs	Periods					
		I	II	III		I	II	III	IV		
11	10	6.28	.....	2.69	8	7.17	3.34	12.1	8.23	5.2	4.34
22	10	4.0	3.15	4.11	8	.....	4.25	3.00	3.43	.....	3.75
23	10	4.20	2.91	3.41	7	5.7	3.35	3.1	2.95	1.96	3.41
24	9	3.62	.....	2.72	8	.....	4.35	2.51	3.00	.....	3.43
49	10	2.13	1.44	.94	7	3.9	1.3	1.76	2.43	1.81	1.92
74	9	1.41	.....	1.08	8	2.3	1.53	.97	1.43	.89	1.29
79	9	1.56	.....	1.22	7	.....	1.96	.89	1.12	.....	1.49
86	10	1.44	.....	.54	8	.....	1.65	.99	1.28	.....	1.14
91	10	1.33	.82	.....	8	1.88	1.17	.58	1.66	.64	.51

consumed food in proportion to their caloric needs. Probably the caloric needs of paired cockroaches were about the same.

Jackson (1937) and McCay and co-workers (1939) in their experiments with rats found that the females needed more calories for maintenance than did the males. In American roaches the average daily food consumption on all diets was equal to 5.9 mg. for males (54 insects) and 6.9 mg. for females (63 insects). However, if only those females that did not produce oothecae were taken into consideration, then the average daily consumption per female (20 insects) was equal to 5.4 mg., somewhat less than in the case of males. Average consumption per mg. of initial weight per 100 days was equal to 0.63 mg. for both males (21 insects) and females (24 insects).

When the average daily consumption was arranged according to the number of the oothecae produced by the virgins of the American roaches on various diets, the results were as follows: those producing

1–5 oothecae (20 ♀♀) consumed 3.5 mg. food daily, 6–10 oothecae (6 ♀♀)—4.5 mg. daily; 11–15 oothecae (5 ♀♀)—5.5 mg.; 16 and more oothecae (10 ♀♀)—4.3 mg. daily. Although only a small

TABLE V

INFLUENCE OF THE CHANGE IN DIET ON URIC ACIDS DEPOSITS IN AMERICAN ROACHES

Original diet protein level per cent	Status at Change		Diet after change	Remarks
	Age in days	Weight in mgs.		
91	1192	1247	91% protein	Lived 112 days. Typical deposits for high protein diet. Gained 132 mg. in 89 days. Daily food consumption 6.5 mg.
91	1192	1440	dextrin	Lived 6 days. Died. Typical deposits.
86	1192	1291	86% protein	Lived 35 days. Typical deposits when died. Daily food consumption 2.7 mg.
86	1192	1026	dextrin	Lived 210 days. At death abdomen shrunk. Fat body meager. White deposits in coxae still present. Lost 75 mg. in 144 days. Daily food consumption 3 mg.
79	1105	1287	79% protein	Died next day. Typical deposits for high protein diet.
79	1105	1166	dextrin	Lived 344 days. Abdomen shrunk, contracted. Fat body very meager, lobules discernible. No white deposits anywhere. Lost 157 mg. in 317 days. Average daily food consumption 6.2 mg.
74	1124	1096	74% protein	Lived 374 days. Typical deposits for high protein diet. Gained 327 mg. in 346 days. Average daily food consumption 6.1 mg.
74	1124	1478	dextrin	Lived 470 days. Abdomen normal. Fat body moderate, lobules discernible. Very slight deposits in coxae still present. Lost 335 mg. in 376 days. Average daily food consumption 6.1 mg.

number of animals was available, it appears that those virgils which produced more oothecae, tended to have a greater food consumption—up to a certain point.

In order to find out what, if any, influence the amount of food

consumed daily had on the longevity of adult cockroaches, they were grouped according to the average daily food and protein consumption.

In the Oriental cockroaches those males whose average daily food intake was equal to 3.5 to 4.5 mg. per day per insect (20 insects), the average longevity was equal to 176 days. Those consuming 4.6 mg. or more daily (17 insects) lived 182 days, which is hardly a significant difference. However, when arranged according to the daily protein intake, those consuming up to 1.5 mg. protein daily (19 insects) lived 231 days and those with an average daily consumption of 1.6–5.5 mg. protein daily (16 insects) lived only 114 days. Apparently the daily level of protein consumption greatly influenced the longevity of the males. In the females, those with daily average total food consumption of 7.5 to 8.5 mg. (25 insects) lived 140 days, those with 8.6 mg. and up (20 insects) lived 134 days. Again there was not much difference. Females consuming 1.5 to 2.5 mg. protein daily (15 insects) lived an average of 194 days; those with protein consumption of 2.6 mg. and higher (27 insects) lived an average of 120 days; this is a considerable difference. When the average longevity was arranged according to the number of oothecae produced by the virgins of Oriental roaches, those virgins which did not produce any oothecae lived 117 days (32 insects), those with 1–5 oothecae (25 insects) lived 137 days and those with 6–15 oothecae (11 insects) lived 190 days. Thus it appears that those with greater longevity produced more oothecae.

In the American roach, males which consumed 3.5 to 5.5 mg. of food daily (17 insects) lived an average of 837 days; those which consumed 5.6 and more (35 insects) lived an average of 636 days. The same tendency was observed when the level of protein consumption was taken into consideration. Males consuming 1.5 to 3.5 mg. protein daily (32 insects) lived an average of 812 days, those consuming 4.6 mg. and more (22 insects) lived an average of only 538 days. There was a significant difference in the longevity of those two groups. Females with an average general daily consumption of 3.5 to 5.5 mg. (13 insects) lived an average of 770 days; those with 5.6 to 6.5 mg. per day (21 insects) lived an average of 644 days, and those consuming 6.6 mg. a day and more (25 insects) lived an average of only 552 days. When the protein consumption was considered, the relation was about the same. Females consuming 1.5 mg. to 3.5 mg. per day (29 insects) lived, on an average, 699 days; those consuming 3.5 mg. and up (30 insects) lived 570 days. When the general food consumption of those virgins which did not produce any egg pods was considered, then those consuming 3.5 mg. to 5.5 mg. a day (10 insects) lived on an average 721 days, those consuming 5.6 mg. and more (10 insects) lived 676 days. As in the case of the males, the heavier eaters lived a shorter time, irrespective of the diet.

When the longevity of virgins of the American roaches was arranged according to the number of the egg pods produced, the females with no oothecae (18 insects) lived 712 days, on an average; those having 1–10 oothecae (25 insects) lived 572 days, and females producing 11–25 egg pods (16 insects) lived 629 days. This is quite different from the results with Oriental cockroaches.

When the life span of the adult American cockroaches was divided

into two periods and the level of consumption was determined in each of these periods separately, than those males which increased their food consumption in the second half of their lives (23 insects) lived 622 days, on an average; those which decreased their average daily food consumption (25 insects) lived 772 days. The females that increased their food consumption (28 insects) had an average life of 649 days, those which decreased (27 insects) lived 637 days. However, when only those virgins which did not produce egg pods are considered, then the picture is entirely different because those which increased their food consumption in the second half of their life (9 insects) lived 773 days, and those that decreased consumption (10 insects) lived 600 days. The protein level of the diet did not play any role in this case, because the average protein level in the first group was 40% and in the second group 37%.

When the longevity of adult American cockroaches was correlated with their daily gain in weight, the results were as follows: the males that gained from 0.1 to 0.3 mg. daily (16 insects) lived 881 days, on an average; those with a gain of 0.4 mg. and more (12 insects) lived only 689 days. Females the weight of which increased by 0.1 to 0.7 mg. daily (12 insects) lived an average of 818 days, those with an increase of 0.9 mg. and more (15 insects) lived 627 days. In both cases those which put on weight more heavily shortened their life span considerably. Of course, one has to remember, that in all cases the increase in weight was probably due to the greater accumulation of the uric acid waste which usually corresponded to the increased protein intake. This was true in this case also, the males and females of the lightly gaining group having, on an average, 25% and 34% protein level of the diet and those of the heavily gaining group 65% and 70% respectively.

The average initial weight of the adult American cockroaches used in the above study on adult longevity was 930 mg. in the male (25 insects) and 1090 mg. in the female (24 insects). These specimens had been reared through the nymphal stadia on the stock diet. When the adult stadium was one-half to three-fourths over the average weight for those fed a diet containing 23–49% protein was 1083 mg. in the male (19 insects) and 1450 mg. in the female (8 insects), whereas those fed a diet containing 74–91% protein averaged 1380 mg. in the male (4 insects) and 1650 mg. in the female (16 insects). The greatest weight attained by American cockroach in this study was 1618 mg. for a male (on 74% protein diet) and 2002 mg. for a female (on 86% protein diet).

The male which attained the largest daily gain in weight (1.1 mg.) was kept on 74% protein diet and lived only 578 days as compared with an average of 704 days for all diets. The female that had the largest daily gain in weight (2.2 mg.) was consuming a diet with 91% protein and lived only 377 days, the average for all females for all diets being 629 days.

The longest life span—from hatching to death—in German cockroaches was in a male on 11% protein diet—516 days. In the Oriental cockroaches the longest life span was attained by a female on 11% protein diet—999 days. The longest life span in the American cockroach was attained by a female on 11% protein diet—1687 days.

The longest adult life in the German cockroach was 324 days for a male and 353 days for a female, both on 11% protein diet. In the Oriental cockroach, it was 350 days for male and 333 days for female, both on 24% protein diet. For the American cockroach, a male lived 1069 days (22% protein) and a female 1043 days (2.5% protein).

Gould and Deay (1938) observed that virgins of American roaches produced egg capsules but that none was fertile. Gier (1947) reported that of 60 virgins kept under observations for two months, none produced any oothecae. In the present experiment more than two-thirds of the virgins produced normal appearing oothecae, which were removed as soon as noticed. There was no special effort to ascertain whether the eggs were viable. However, in three cases newly hatched nymphs were observed to have been produced parthenogenetically. The cases follow:

1. Female on 79% protein diet; lived 710 days; produced 21 oothecae. The sixth ootheca, deposited at 309 days, produced parthenogenetic nymphs.

2. Female on 74% protein diet; lived 622 days; produced 14 oothecae. The twelfth ootheca, deposited at 353 days, produced parthenogenetic nymphs.

3. Female on diet of 74% protein; lived 706 days; produced 13 egg pods. The fifth ootheca, deposited at 407 days, produced parthenogenetic nymphs.

Maluf and Rustum (1939) reported that the Oriental cockroach can live without food or water at room temperature for 20 to 60 days. In the present experiments two female Oriental cockroaches of unknown age starving without water available lived 11 and 12 days respectively. Under the same conditions two male cockroaches lived 6 and 11 days respectively. When water was supplied during starvation, the females lived 20, 21 and 22 days while a male lived 16 days.

Some pathological phenomena were observed during the experiment. Dark brown bodies, somewhat resembling eggs were present in the abdomens of 6 dissected females of American cockroaches and of three males. In some specimens there were several dozen of these bodies.

It was noticed also that on high protein diet (74% and over) the feces of the Oriental and American cockroaches tended to be liquid and of a whitish color.

SUMMARY

German, Oriental and American roaches were fed diets containing various levels of proteins The most favorable level for the development of the German and Oriental cockroaches was in the range of 22–24%; for the American cockroach the range was somewhat wider and higher. The amount of protein consumed daily by the adults seems to be inversely correlated with the longevity of the individual. The total life span of the experimental animals also decreased with the increase of the protein level of the diet. None of the German nymphs reached maturity on the diets containing 86–91% protein.

There were large white deposits in the fat bodies of the cockroaches fed higher protein diets. These deposits give a positive murexide

test and so presumably are urates or uric acid. The deposits greatly dimninished when the diet of such insects was changed to pure dextrin, and the longevity of the individuals was increased in comparison with those continued on the original diet.

The protein efficiency ratio in general decreased with increasing protein level of the diet and with increasing age of the insect.

The individual level of protein consumption greatly influenced the longevity of the Oriental and American roaches. Those consuming more protein had shorter lives. In the American heavier eaters lived a shorter time, irrespective of the diet. Those American male cockroaches which decreased their food consumption in the second half of their lives lived longer than those which increased food consumption. Both males and the females of American roaches which put on more weight per day had shorter lives than those which did not gain as rapidly.

Parthenogenesis in American cockroaches was observed in several cases.

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REVISTA ECUATORIANA DE ENTOMOLOGIA Y PARASITOLOGIA.

New periodicals to take care of the entomological papers coming from South America are much needed, so this is a welcome addition to the field. The editors promise to publish articles "within three months after the reception of the original manuscript on any speciality on Entomology or Parasitology, either medical, sanitary, veterinary or applied agricultural," will probably prove too optimistic, but we wish him all success in his admirable ambition.

Volume 1, number 1, is dated January, 1953, and contains 45 pages devoted to an article on the historical development of our knowledge of Ecuadorian Tipulidae, by C. P. Alexander, three articles on neotropical mosquitoes by Roberto Leví-Castillo, and some notes and reviews of literature. The editor is Dr. Roberto Leví-Castillo, Centro Ecuatoriano de Investigaciones Entomológicas, Apartado 3606, Guayaquil, Ecuador, S. A. The annual subscription rate is $5.00 (U. S. currency). Publication is scheduled for January, April, July, and October of each year.—M. T. J.

THE UNGUITRACTOR PLATE AS A TAXONOMIC TOOL IN THE HEMIPTERA[1]

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Morphology deals with the relation of structure to function. This is not teleological reasoning, because the structure has first to be discovered, then its function determined by experimentation; there are many described structures, whether on the microscopic or gross level, whose function is either unknown or dubious. The discovery of new structures, and learning their function, may elucidate the physiological, ecological, or taxonomic function of the structure. Hence, the finding of new structures is of never-ending importance, and noting their similarities and dissimilarities is essential for the unanimity of the purpose of systematics. The unguitractor plate, which is a part of the pretarsus, offers another addition to the structures of taxonomic value to the systematist. Its intrinsic value is not readily observable, because the unguitractor is small. But any structure, no matter how obscure, can be an aid and of significance in the comprehension of taxonomy and phylogeny. This work does not intend to examine the relative positions of the categories studied, but to present another morphological structure to aid the entomologist.

MATERIALS AND METHODS

The specimens used for this study were obtained from collecting, the collection of the Department of Entomology of the University of Illinois, and the Faunistic Survey Section of the Illinois State Natural History Survey.

Since the unguitractor plate is a constituent of the pretarsus, it is necessary to dissect the pretarsus from the distitarsus. The distitarsus was removed from the remainder of the tarsus, where possible, or the whole tarsus was separated from the tibia. Either structure was boiled in 10 percent potassium hydroxide for various lengths of time. The time value was dependent upon the amount of sclerotization of the tarsi or distitarsi. For example, the phymatid tarsi were boiled for less than a minute, while the belostomatid tarsi were boiled for nearly five minutes. After the structure had been softened and cleared sufficiently, the pretarsus was dissected out under the binocular microscope. This was accomplished by pinching the distitarsus with one forceps and the claws with another pair of forceps and gently pulling the forceps in opposite directions. The pretarsus was easily isolated, and whenever feasible, *i.e.*, when the pretarsus was large, as in Cydnidae, as opposed

[1]Contribution from the Entomological Laboratory of the University of Illinois.

[2]This work is part of a thesis required in partial fulfillment of a Master of Science degree at the University of Illinois. I would like to extend my appreciation to Professor William P. Hayes, under whose direction this thesis was completed.

to small in Cimicidae, the unguitractor was dissected from the rest of the pretarsus. Twenty families of Hemiptera were studied. They include:

Cynidae	Aradidae	Nabidae	Naucoridae
Scutelleridae	Neididae	Cimicidae	Nepidae
Pentatomidae	Lygaeidae	Miridae	Belostomatidae
Coreidae	Phymatidae	Gerridae	Notonectidae
Rhopalidae	Reduviidae	Gelastocoridae	Corixidae

Important families, like the Tingidae, have been omitted because their inclusion would not add greatly to the basic assumption of this investigation.

DESCRIPTIONS OF THE UNGUITRACTOR PLATE

The families included among the descriptions are arranged according to Essig (1947) and the subfamilies, tribes, genera, and species according to Blatchley (1926). The name Corizidae, as mentioned in Essig, has now been corrected to Rhopalidae (Harris 1942).

Cydnidae

Cyrtomenus mirabilis (Perty) (Fig. 1). The unguitractor plate is shield-shaped, its base is truncate, and the sides are parallel for a short distance from the base, then widely divergent. The laterodistal area is broad and bends anteriomesad to the lateral margin of the empodium. At the margin of the empodium it bends posteriomesad to form a "V"-shaped emargination, and the base of the emargination is truncate.

The empodium is flask-like. Its proximal area is trangulate, and mesal area neck-like, *i.e.*, the sides are parallel. From the sides are lateral projections which form a wide "V".

The parempodia are long and arise from the projections of the empodium.

Pangaeus bilineatus (Say) (Fig. 2). The unguitractor is shield-shaped, its base is truncate, and the sides parallel for a short distance from the base, then the sides diverge widely. The distolateral margins are not very broad and bend slightly anteriomesad to the lateral margin of the empodium to form a wide "U"-shaped emargination whose base is slightly rounded.

The empodium is subhexagonal, its distal projections are rectangulate and the sides of the projection parallel.

The parempodia are long and setiform and arise from the projections of the empodium.

COMPENDIUM: The unguitractor of the Cydnidae is shield-shaped and its base is truncate with sides parallel which later diverge. This basal portion is not the tendon, for this area recurves (Fig. 4b) and the tendon is united to the recurved portion of the plate. The two species studied differ most strikingly in the appearance of the empodium where *Cyrtomenus mirabilis* is flask-shaped and that of *Pangaeus bilineatus* subhexagonal.

Scutelleridae

Tetrya bipunctata (H.-S.) (Fig. 3). The unguitractor (Utr.) is shield-shaped, and its base is truncate with its sides widely divergent. The distolateral margins end in a triangulate point.

The empodium is rectangulate, its base depressed, and the distal area is emarginate. The emargination is rectangular. The base of the emargination is truncate and the sides parallel. Distad of the empodium is the planta (P). It is composed of two sclerites and each bear one seta. The position of this seta may be mistaken for the absent parempodia.

Diolcus chrysorrhoeus (Fabr.) (Fig. 4a). The unguitractor is shield-shaped, its base truncate, with the sides parallel for a short distance, then diverging widely. The distolateral margins end in a triangulate point.

The empodium is rectangulate, its distal margin divides to form a "V". The distal area of the "V" widens laterad and is sclerotized at its distal margin.

The parempodia are long and arise from the distal area of the empodium.

The lateral view (Fig. 4b) clearly shows that the base of the plate recurves. It is on this recurved portion of the unguitractor plate that the tendon is fixed. The remaining portion of the plate and empodium and parempodium are the same.

COMPENDIUM: The distolateral margins come to a triangulate point. The empodia are rectangulate, and the Parempodia of *Tetrya bipunctatus* are absent, while it is present in *Diolcus chrysorrhoeus*.

Pentatomidae

Brochymena quadrapustulata (Fabr.) (Pentatominae, Halyini) (Fig. 6). The unguitractor is shield-shaped. Its base is rounded. The latero-distal margins are slightly oblique, and a mesal rectangular area is striped transversely.

The proximal area of the empodium is quadrate, and it widens distad. The anterolateral projections are trapezoidal.

The parempodia are moderately long and setiform and arise from the projections of the empodium.

Acrosternum hilare (Say) (Pentatominae, Pentatomini) (Fig. 6). The unguitractor is shield-shaped, the base rounded and the distal margin emarginate. The emargination is rectangular and its base truncate. The mesal quadrate area is striped transversely.

The empodium is rectangulate. The anterolateral area projects anteriorly to form an emargination. The base of the emargination is truncate, its sides parallel, and the distal area of the projection widens laterad and is also sclerotized.

The parempodia are long and setiform and arise from the sclerotized area of the distal projections of the empodium.

Perillus bioculatus (Fabr.) (Asopinae) (Fig. 7). The unguitractor is shield-shaped, and the base is truncate. The sides are parallel for a short distance, then divergent. The distolateral margin is rounded, and the mesal triangular area is striped transversely.

The lateral margins of the empodium are slightly bulbous proximad and then become concave. The lateral projections are rectangulate.

The parempodia are thin, long, and setiform and arise from the projections of the empodium.

Podisus maculiventris (Say) (Asopinae) (Fig. 8). The unguitractor is

shield-shaped, the base truncate, and the sides parallel for a short distance, then divergent. The distolateral margins are obliquely truncate. The distal margin is deeply emarginate.

The empodium is rectangulate on its proximal margin. The lateral margins are parallel from the distal margin of the unguitractor to the mesal area, then diverge. The distal projections present widens lateromesad. The parempodia are moderately long, thin and setiform and arise from the margin of the distal projections of the empodium.

COMPENDIUM: All the unguitractor plates of the Pentatomidae are shield-shaped, and there is a mesal area that is striped transversely, except in *Podisus maculiventris*. The base of the unguitractor in the Asopinae is truncate. The empodia are rectangulate; there is a great diversity of form distad.

Coreidae

Merocoris distinctus Dallas (Marocorinae) (Fig. 9). The unguitractor is subquadrate and wide. There is a triangular mesal area that divides the unguitractor into two lateral lobes. The posterior margin is concave and the anterior margin is truncate mesally and lobate laterally. The empodium is transversely narrow and the distal projections arise as thin necks which widen on their lateral margins. The distal portion is sclerotized and bears setiform parempodia.

Anasa tristis (Deg.) (Coreinae, Coreini) (Fig. 10). The unguitractor is subquadrate and its proximal emargination is concave. There is a wide hour-glass-shaped mesal area that divides the unguitractor into two lateral lobes. The posterior mesal margin is concave and its distance between the lateral lobes is wider than the anterior portion, whose margin is also concave.

The proximal area of the empodium is quadrate, and its base is rounded. The distal area is divided into a "V", and the distal end of the "V" is slightly sclerotized.

The parempodium are long and setiform and arise from the distal margins of the "V".

COMPENDIUM: The unguitractor of the Coreidae is subquadrate and has a mesal sclerotized area that divides the plate into two lateral lobes. The sclerotized area of *Merocoris distinctus* is triangulate, and that of *Anasa tristis* hourglass-shaped. The empodium of *M. distinctus* is narrow proximad, and its projections are lobiform. The proximal area of *A. tristis* is quadrate and the distal projection is not lobiform.

Rhopalidae

Narmostes reflexulus (Say) (Harmostini) (Fig. 11). The unguitractor is subquadrate, and the base is concave. A mesal sclerotized area forms an inverted "T" and does not reach the distal margin of the plate. Its posterior region reaches the proximolateral angles of the plate. The distolateral margins are rounded. The empodium is rectangular and membranous. It does not bear parempodia.

Leptocoris trivittatus (Say) Leptocorini) (Fig. 12). The unguitractor is subrectangular, it base truncate, and sides somewhat divergent. An anterior emargination is wide and rectangulate. A mesal sclerotized triangulate area is present which forms an inverted "T" and touches the proximolateral margins.

The proximal area of the empodium is quadrate. The distal portion does not bear parempodia.

COMPENDIUM: Both species of Corizidae studied have a mesal inverted "T"-shaped sclerotized area on the unguitractor which touches the proximolateral margins of the unguitractor. The arm of the inverted "T" of *H. reflexulus* does not reach the distal margin of the unguitractor. Both empodia are rectangulate and both do not have parempodia.

Aradidae

Aradus debilis (Uhler) (Aradinae) (Fig. 13). The unguitractor plate is shaped like an arrowhead, narrows greatly proximad, and the base is truncate. The laterodistal margins are rounded. The proximal sides are nearly parallel for a short distance then diverge.

The empodium is pedicellate and wide.

The parempodia are moderately long and setiform and proximally joined to form a "U".

Neuronectus pseudonymus Bergroth (Mezerinae) (Fig. 14). The unguitractor is shaped like an arrowhead, being broad distad, and narrows greatly proximad. The proximal margin is triangulate. The proximal sides are parallel for a short distance, then diverge.

The empodium is pedicellate and not very wide.

The parempodia are moderately long and setiform and proximally joined to form a "V", being nearly contiguous.

COMPENDIUM: The general arrowhead-shaped unguitractor plate is common to the two subfamilies of Aradidae studied. The species differ in the dimensions of the unguitractor and the empodium.

Neididae

Neides muticus (Say) (Fig. 15). The unguitractor plate is subquadrate, and its base concave. The sides are subparallel, and at the distal margin, forms a sclerotized loop. A mesal triangular area is present, and it lies in a quadrate region that is not membranous, yet not as heavily sclerotized as the region adjacent to it.

The empodium is quadrate and membranous. On its distal border, it bears a pair of parempodia which are difficult to see because they are thin and transparent; therefore, their silhouette is not distinct.

Jalysus spinosus (Say) (Fig. 16). The unguitractor is rectangulate, and the base truncate. The sides are subparallel. A mesal triangular-shaped sclerotized area, one half the length of the unguitractor, with its apex anterior, lies in a small mesal subquadrate membranous area.

The empodium is an extension of the membranous area of the unguitractor, and is rectangulate proximad. The sides are curved.

The parempodia are moderately long and setaform and arise from the distal margins of the empodia.

COMPENDIUM: The chief diagnostic feature of the Neididae is the triangular sclerotized area in the mesal portion of the unguitractor plate. Both empodia are membranous. The major difference between the two is the sclerotized anterior margin of the unguitractor and the looped region in *N. muticus* and not in *J. spinosus*.

Lygaeidae

Lygaeus kalmii (Stal) (Lygaeinae) (Fig. 17). The unguitractor and its base is slightly concave. The posteriolateral margins are rounded, and the posteriomesal margin is concave. A mesal sclerotized triangulate area widens posteriorly to touch the inner posteriolateral angles.

The empodium is "U"-shaped. The proximal margin is truncate, and the sides form lateral projections. The distal area of the projections widens laterad.

The parempodia arise from the distal sclerotized part of the "U". They are long, thin, and setaform.

Ischnodemus falicus (Say) (Blissinae) (Fig. 18). The unguitractor is quadrate, and its base is concave. A mesal sclerotized triangular-shaped area, resembling an inverted "T", is present.

The empodium forms a "V"; the terminal ends of the "V" are sclerotized, and the base has no pedicellate proximal region. The parempodia originate from the distal sclerotized area of the empodium.

Myodocha serripes (Olivier) (Rhyparochrominae, Myodochini) (Fig. 19). The unguitractor is subshield-shape, slightly concave at the base, and has a deep distal emargination. The base of the emargination is truncate. The distolateral margins are rounded. A mesal sclerotized triangular-shaped region that widens at the base is present in the unguitractor.

The proximal part of the empodium is pedicellate. On a transverse plane with the distal margins of the unguitractor the empodium divides and forms a "V". At the distal sclerotized area of the "V" arise the setiform parempodia.

COMPENDIUM: The unguitractors vary in shape and form, but they all have a mesal triangular sclerotized area. The empodia divide distad in the form of a "U" or a "V". The distal ends of the empodium are sclerotized and bear setiform parempodia.

Phymatidae

Phymata pennsylvanica americana (Melin) (Fig. 20 a, b). The unguitractor plate is elongate and more nearly ovate. The base is

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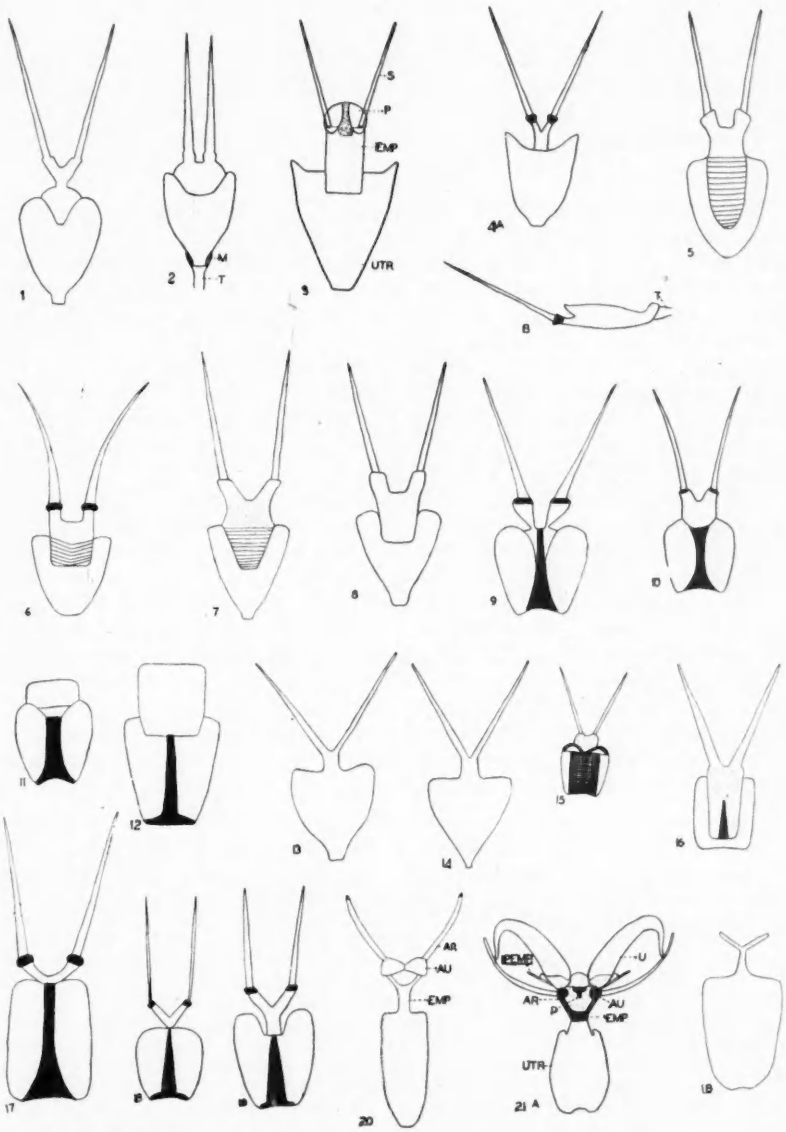
EXPLANATION OF PLATE I

Unguitractor plates of Hemiptera. FIG. 1. *Crytomenus mirabilis* (Perty) (Cydnidae). FIG. 2. *Pangaeus bilineatus* (Say) (Cydnidae). FIG. 3. *Tetrya bipunctata* (H.-S.) (Scutelleridae). Note the planta (P) in close association with the empodium and the setae borne by the planta. FIG. 4. *Diolcus chrysorrhoeus* (Fabr.) (Scutelleridae); A, ventral aspect; B, lateral aspect. Note the unguitractor tendon (T), and the position of the tendon arising from the base of the unguitractor. FIG. 5. *Brochymena quadrapustulata* (Fabr.) (Pentatomidae). FIG. 6. *Acrosternum hilare* (Say) (Pentatomidae). FIG. 7. *Perillus biolatus* (Fabr.) (Pentatomidae). FIG. 8. *Podisus maculiventrus* (Say) (Pentatomidae). FIG. 9. *Merocoris distinctus* Dallas (Coreidae). FIG. 10. *Anasa tristis* (Deg.) (Coreidae). FIG. 11. *Harmostes reflexulus* (Say) (Rhopalidae). FIG. 12. *Leptocoris trivittatus* (Say) (Rhopalidae). FIG. 13. *Aradus debilis* (Uhl.) (Aradidae). FIG. 14. *Neuronectus pseudonymus* Bergroth (Aradidae). FIG. 15. *Neides muticus* (Say) (Neididae). FIG. 16. *Jalysus spinosus* (Say) (Neididae). FIG. 17. *Lygaeus kalmii* (Stal.) (Lygaeidae). FIG. 18. *Ischnodemus falicus* (Say) (Lygaeidae). FIG. 19. *Mydocha serripes* (Olivier) (Lygaeidae). FIG. 20. *Phymata pennsylvanica americana* (Melin) (Phymatidae). FIG. 21. *Melanolestes picipes* (H.-S.) (Reduviidae). A. Top view of pretarsus. Note the relationship between the parempodia and arolia and arcus. B. Ventral aspect of the unguitractor plate.



Unless otherwise noted, all illustrations were drawn from the fore pretarsus; ventral aspect, unless otherwise stated. Abbreviations:

AU—Arcus
AR—Arolium
EMP—Empodium
FM—Flexor Membrane
M—Membrane
P—Planta
PA—Palea
PEMP—Parempodium
S—Seta(e)
T—Unguitractor Tendon
U—Ungues
UTR—Unguitractor Plate

truncate. The sides are widely divergent, and the distal margin bends mesad.

The empodium is pedicellate, and the distolateral sides diverge to form two arms. The arms unite with the proximolateral margin of the arcus.

Parempodia are not present. The arolium is present.

Reduviidae

Melanolestes picipes (H.-S.) (Piratinae) (Fig. 21 a, b). The top view of the pretarsus (Fig. 21a) indicates how confusion may arise between parempodia and arolia. At the distal margin of the empodium is the sclerotized arcus and its arolia. Dorsad of the arolia setiform membranous parempodia can be seen. The parempodia, therefore, lies between the claws and arcus. The ventral view (Fig. 21b) illustrates the subovate unguitractor with its concave proximal margin, and the pedicellate empodium that divides distad. The empodium is slightly sclerotized. The distal margin of the empodia bear the membranous parempodia. The parempodia are not seen from the ventral view, because they arise behind the arolia.

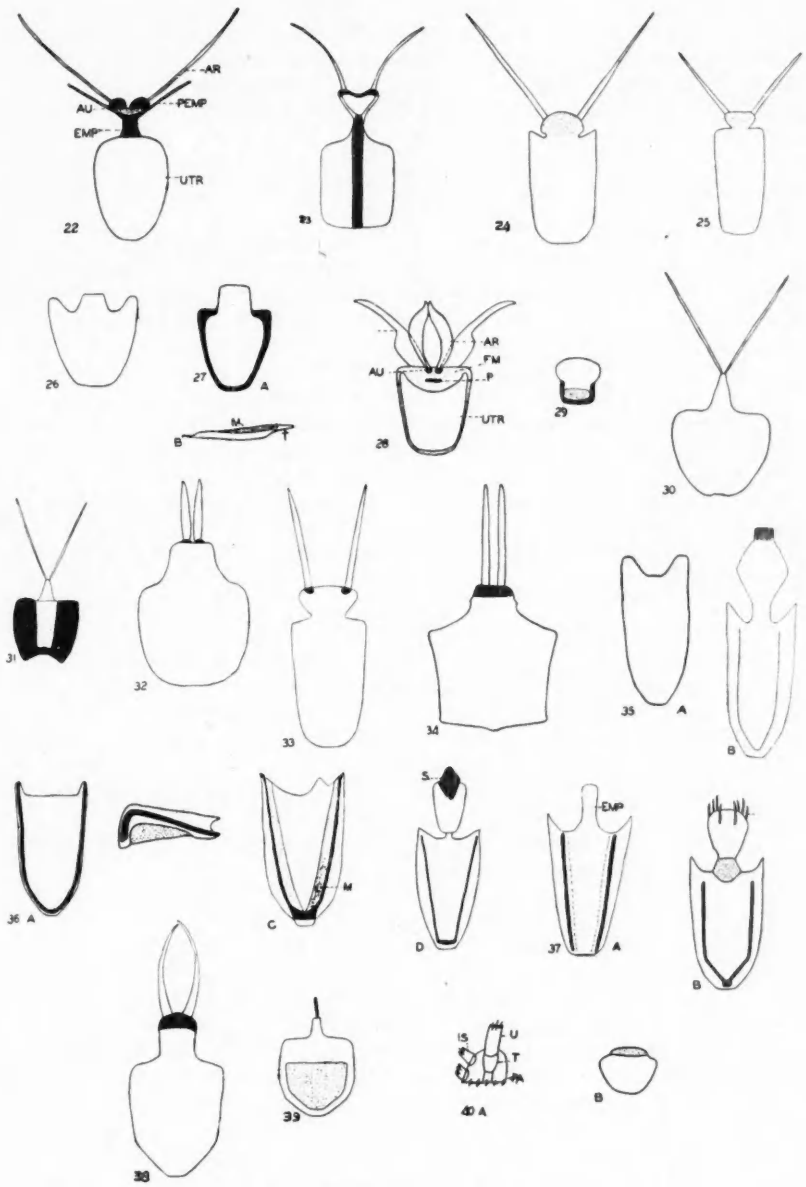
Apiomerus crassipes (Fabr.) (Apiomerinae) (Fig. 22). Here we have a similar situation that exists with the parempodia of *M. picipes* and its position with relation to the arcus. The arcus is sclerotized and separated from the empodium by a membranous area.

The unguitractor is ovate, and its base is truncate. The empodium is rectangulate and divides laterally distad. From the distal extensions the parempodia arise. The empodium is slightly sclerotized.

Sinea diadema (Fabr.) (Fig. 23). (Zelinae) The unguitractor is quadrate, the base truncate, and the sides subparallel. The distal margin bends mesad and forms an anterior projection that unites with the empodium. A mesal sclerotized striped region extending the entire length of the unguitractor terminates at the empodium.

EXPLANATION OF PLATE II

Unguitractor plates of Hemiptera. FIG. 22. *Apiomerus crassipes* (Fabr.) (Reduviidae). Note the relationship between the empodium and parempodium between the arcus and arolia. FIG. 23. *Sinea diadema* (Fabr.) (Reduviidae). FIG. 24. *Nabus ferus* (L.) (Nabidae). FIG. 25. *Cimex lectularius* (L.) (Cimicidae). FIG. 26. *Miris dolobratus* (L.) (Miridae). FIG. 27. *Lygus obliniatus* (Say) (Miridae). A, ventral aspect; B, lateral aspect. Note the origin of the unguitractor tendon. FIG. 28. *Lopidia davisi* (Knight) (Miridae). Note the unguitractor plate is surrounded by membrane and flexor membrane. FIG. 29. *Plagiognathus politus* (Uhl.) (Miridae). FIG. 30. *Gerris remigis* (Say) (Gerridae). FIG. 31. *Metrobates hesperius* (Uhl.) (Gerridae). FIG. 32. *Gelastocoris oculatus* (Fabr.) (Gelastocoridae). FIG. 33. *Pelocoris femoratus* (Palisot de Beauvois) (Naucoridae). FIG. 34. *Ranatra nigra* (H.-S.) (Nepidae). FIG. 35. *Benacus griseus* (Say) (Belostomatidae). Unguitractor plate of: A, fore pretarsus; B, mid pretarsus. Note the setae arising from the empodium. FIG. 36. *Lethocerus americanus* (Leidy) (Belostomatidae). Unguitractor plate of fore pretarsus: A, ventral aspect; B, lateral aspect; C, dorsal aspect of mid pretarsus: D, ventral aspect. FIG. 37. *Belastoma fluminea* (Say) (Belostomatidae). A, fore pretarsus; B, mid pretarsus. Note the eight setae arising from the empodium. FIG. 38. *Notonecta irrorata* (Uhl.) (Notonectidae). FIG. 39. *Buenoa elegans* (Fieb.) (Notonectidae). FIG. 40. *Hespercorixa alternata* (Say) (Corixidae). A, lateral aspect of fore pretarsus. Note the unguitractor tendon and claw directly attached. B, mid pretarsus, ventral aspect of unguitractor plate.



(See page 567 for explanation of abbreviations)

The distal margin of the empodium, which is membranous and triangulate, is adjacent to the sclerotized basipulvilli. The arcus is easily confused with the base of the parempodia. This dilemma is readily solved if we realize the difference in structure between the thin membranous parempodia as compared to a heavily sclerotized base and a slightly sclerotized arolium. The pulvillus of the pretarsus is modified to form an adhesive pad (Tower 1913).

COMPENDIUM: If the parempodia are present, they arise from the distal lateral projections of the empodia. The unguitractor varies in shape.

The distal margins of the empodia are closely associated with the arcus; therefore, the parempodia can be easily confused with the arolia. This can be rectified by noting that the parempodia are membranous and setiform while the arolia are sclerotized, long, and curved.

Nabidae

Nabis ferus (L.) (Nabinae) (Fig. 24). The unguitractor plate is rectangular and the sides parallel. The proximal margin is truncate, and the sides are widely divergent at the base. The distolateral margins project forward and come to a sharp point.

The empodium is bulbous. The proximal area is wide and diverges laterad into an oval bulb.

The parempodia are long and setiform and arise from the mesolateral margins of the empodium.

Cimicidae

Cimex lectularius (L.) (Fig. 25). The unguitractor plate is elongate, rectangular, and truncate at the base. The sides are divergent. The distal margins bend mesad. The plate resembles that of *Nabis ferus* (Fig. 24), but the distolateral margins do not project forward or come to a point.

The empodium is not pedicellate, as in *Phymata pennsylvanica americana*. The distolateral margins are rounded.

The parempodia are moderately long and setiform and arise from the distolateral margins of the empodium.

Miridae

Miris dolobratus (L.) (Mirinae) (Fig. 26). No parempodia are present, but the presence of the arcus and the clavate arolia in the general locality as the parempodia might lead to some confusion. This assumption is easily negated by the definition of arolia and arcus. These structures are used to identify Miridae (Knight 1941) (Fig. 28). In fact, the classification of subfamilies and tribes in this family is based almost entirely on the structure of the pretarsus.

The unguitractor is shield-shaped. The base and distolateral margins are slightly rounded. The distal margin is emarginate and continuous with the quadrate empodium whose terminal margin is slightly longer than the distal margin of the unguitractor.

Lygus oblineatus (Say) (Capsinae, Capsini) (Fig. 27). The unguitractor is shield-shaped, and the base truncate. The sides are divergent and sclerotized.

The quadrate empodium is truncate and does not bear parempodia. The lateral view (Fig. 27b) shows the recurved proximal area where the tendon (T) is attached. The dorsal surface is surrounded by membrane.

Lopidia davisi (Knight) (Ortholyinae, Lopidini) (Fig. 28). The unguitractor is subrectangulate, the base truncate, and the distal margin is emarginate.

There is no empodium. A small, narrow sclerotized area may be seen in the region of the empodium, the planta. Here too confusion might arise between the parempodia and arolia.

Plagiognathus politus (Uhler) (Phylinae, Phylini) (Fig. 29). No parempodia or empodium are present. The unguitractor is bulbous distad and quadrate proximad. The margin of the proximal part is sclerotized. There is also a membranous area in the proximal area of the plate.

COMPENDIUM: The unguitractor varies in shape from shield-shaped to quadrate. The Mirinae and Capsinae resemble each other more than is the case with Phylinae and Ortholyinae, which do not resemble each other. Empodia were present only in *Miris dolobratus*, and *Lygus oblineatus*, and they are quadrate. There are no parempodia. However, one may compare the arolia of *Lygus oblineatus* and *Lopidia davisi* with the parempodia. This misconception is excluded if we recall that the arolium is a median pad-like or setiform structure between the basis of the claws which alternate with the unguifer. Also when dissecting out the unguitractor, there is no seta-like structure arising from it, hence the ambiguity of the parempodia is omitted. A planta is present on the ventral surface of the pretarsus of *Lopidia*.

Gerridae

Gerris remigis (Say) (Gerrinae) (Fig. 30). The unguitractor is subcircular and very wide. The proximal margin has a small emargination and the sides are divergent. The laterodistal margins are rounded and bend mesad.

The empodium is pyramidal, and the distal margin truncate.

The parempodia are thin, moderately long setiform, nearly continuous, and originate from the distal margin of the empodia.

Metrobates hesperius (Uhler) (Halobatinae) (Fig. 31). The claws do not extend from the terminal margin of the tarsi, instead they arise from the median ventral surface of the distitarsus.

The unguitractor is quadrate, and its base is deeply emarginate. There is a mesal membranous area, while the remainder of the plate is sclerotized.

The empodium is pyramidal, and the distal margin is truncate. The distolateral margin bears two thin, nearly contiguous parempodia.

COMPENDIUM: The empodia of the Gerridae studied are pyramidal, and the distal margin is truncate. The parempodia are thin and originate from the distolateral margin of the empodium. The unguitractor plates are very different; for example, a subcircular, nonsclerotized plate occurs in *Gerris remigis*, as opposed to the heavily sclerotized sides, median membranuous area, and quadrate plate of *Metrobates hesperius*.

Gelastocoridae

Gelastocoris oculatus (Fabr.) (Fig. 32). The unguitractor plate is subcircular, and very wide. The base is subquadrate, the sides rounded, and the distad margin bends slightly anteriomesad.

The empodium is fused with the unguitractor, it is trapezoidal, and one-half as wide as the unguitractor. The distomesal margin has a very slight distal emargination. There is a slight ridge adjacent to the depression.

The parempodia are short, wide, ellipsoidal, with the apex pointed, and arise from the ridge of the empodium.

Naucoridae

Pelocoris femoratus (P. de B.) (Fig. 33). The unguitractor plate is rectangular, and its base is truncate. The sides are divergent and distally bend anteriomesad.

The empodium is subovate. The sides are widely divergent, and the distal margins slightly rounded. On the anterior margin a short distance from the lateral margins there are a pair of circular sclerotized areas which bear the parempodia. The parempodia are wide and moderately long.

In his monograph on *Naucoris cimicoides* (L.) Rawat (1939) says of the fore tarsi and tibia, that "the tibia and tarsus form one compound segment, the latter ending in a black claw-like structure". Since a claw is not present in the fore limb of Naucoridae, it follows that an unguitractor plate would not be present and this is the case. Therefore, the midtarsi were examined in *Pelocoris*.

Nepidae

Ranatra nigra (H.-S.) (Fig. 34). The unguitractor is quadrate and very broad. The base is slightly angulate with its mesal margin slightly rounded. The distolateral margins are curved mesad.

The basal portion of the subrectangulate empodium has its sides parallel, then they bend mesad to the distal truncate margin which bears two parempodia. The distal area of the empodium is sclerotized.

The fore tarsi were not used because it is unisegmented and does not bear a claw. The tarsus fits into a tooth projecting from the femur. Hamilton (1931) mentions the pretarsus of *Nepa cinera* (L.) but does not describe it.

Belostomatidae

Benacus griseus (Say) (Fig. 35). The foreleg has but one claw. The unguitractor plate is shield-shaped. The base is truncate, and the sides are divergent. The distal area is deeply emarginate, the distolateral angles project, and the inner margin bends posteriomesad. The base of the emargination is truncate (Fig. 35a).

Both the empodium and parempodia are absent.

The mid-leg has two claws. The unguitractor is shield-shaped. The base is truncate, and the sides divergent at the base. The distolateral angles come to a point, and the apex of the point bends posteriomesad (Fig. 35b).

The empodium is pedicellate proximad, hexagonal distad. The sides of the pedicel diverge outward for one-half the length of the empodium, then bend mesad until the inner margin is on the same plane as the lateral margin of the pedicel. It is capitate in shape. The distal margin is truncate and bears many setae and no parempodia.

Lethocerus americanus (Leidy) (Fig. 36 a, b, c, d). The foreleg possesses only one claw. The unguitractor is shield-shaped and broader than that of *B. griseus*. Continuous with the entire margin, except the transverse distal margin, is a sclerotized band. The lateral view (Fig. 36b) shows that the base of the plate recurves, and the tendon is attached on the proximal side of the recurved part. A sclerotized band runs along the margin and widens proximad. Inspection of the dorsal surface reveals an evagination from the distal surface and the distolateral margin coming to a point. Also, the distal margin of the ventral emargination is truncate, while that of the dorsal margin is concave with a projecting area. These differences are due to the width of the distal area of the plate which allows for a variation of the margins (Fig. 36c).

The mid-leg has two claws. The unguitractor plate is more ovoid than in *B. griseus*. The distolateral margins are pointed, and a sclerotized band runs along the sides of the plate.

The proximal portion of the empodium is pedicellate. The anterior portion is rectangular and two-thirds the distance from the pedicel many setae arise. There are no parempodia. (Fig. 36d).

Belostoma fluminae (Say) (Fig. 37 a, b). Only one claw is on the foreleg. The unguitractor is shield-shaped, and has a truncate base. A short distance entad from the sides is a sclerotized band. The distolateral margins come to a point, and from the mesodistal margin an empodium originates. The empodium is rectangulate and does not bear either setae or parempodia. (Fig. 37a).

Two claws are on the mid-leg and the unguitractor is shield-shaped, truncate at the base, and its distolateral margins come to a point. There is a distal emargination. Between the distal margins of the central emargination and the distolateral margin which comes to a point, there is a flat, plateau-like area. (Fig. 37b).

The proximal region of the empodium is hexagonal and membranous. The distal region is clavate and bears eight setae, but no parempodia. Six setae are situated on the laterodistal margin, and two setae arise in a plane below the most entad setae.

COMPENDIUM: The fore, uniclawed pretarsus has a shield-shaped unguitractor and truncate at the base. *Benacus griseus* does not show any evidence of an empodium, but *L. americanus* does have an evagination of the distal margin on its dorsal surface. This evagination might be considered as the anlage of the empodium. This hypothesis is plausible after we examine the unguitractor plate of *Belostoma fluminae* which does have an empodium.

The distolateral margins of the plate are pointed in *Belostoma fluminae*, while those of *L. americanus*, except the dorsal margin, and *B. griseus* are truncate.

The two-clawed pretarsus bears no parempodia on their empodia,

instead setae arise from their distal margins. The number of setae vary from few to many. The proximal region of the empodia are pedicellate except in *B. fluminae*. The distinguishing factors of this group are the shield-shaped unguitractor and setae from the empodia.

Notonectidae

Notonecta irrorata (Uhler) (Fig. 38). The unguitractor plate is spade-shape. The base is truncate, and the sides widely divergent. One-third the distance from the base the lateral margins become parallel and the distal margins bend slightly anteriomesad.

The empodium is rectangulate, the distal margin is slightly rounded, and possesses two lateral ridges which bear the moderately setiform parempodia. The distal area of the empodium is sclerotized.

Buenoa elegans (Fieb.) (Fig. 39). The unguitractor plate is spade-shaped. The base is truncate, and the sides are widely divergent. One-third of the distance from the base the diverging sides bend anteriorly and their distal margin turns anteriomesad. A large central area is membranous.

The empodium is rectangulate or subpyramidal.

The parempodia are very fine and thread-like and appear as fine hairs projecting from the empodium.

COMPENDIUM: The unguitractor plates have the shape of a spade. The empodia are rectangulate. They differ in that the unguitractor of *N. irrorata* is narrower than that of *B. elegans*, and there is a large central membranous area in the plate of *Buenoa*. The distal margin of the empodium of *Notonecta* is ridged, while this is not the case in *Buenoa*.

Corixidae

Hespercorixa alternata (Say) (Fig. 40b). The unguitractor plate is subquadrate, and bowl-shaped. The distolateral margins bend anteriomesad, and the base is truncate. From the base, the sides are widely divergent.

The empodium is transversely elipsoidal and short. There are no parempodia.

The mid-leg of this species was examined instead of the fore-leg. The first tarsal segment of the Corixidae is called a "pala", and it has one simple claw. The pala is not usually fused with the tibia, but there are a few species in which they are fused. The shape of the pala is variable, but generally spoon-shaped and bearing many strong bristles that aid in the gathering of food which is organic ooze (Hungerford 1948). Herbivorous material comprise the major portion of organic ooze utilized by the Corixids. The pala shows a case of a simple pretarsus, the tendon is directly affixed to the claw. Griffith (1945) says, of the prothoracic pretarsus, that it is "provided with a tendon and flexor muscle, and serving as an active raptorial element in the setal basket of the tarsus." The mesotarsi of the Corixidae are uni- or bi-segmented and bear two long claws. These claws act as anchors. Figure 40a illustrates the simple pretarsus of Corixidae.

KEY TO SOME FAMILIES OF HEMIPTERA, BASED ON THE UNGUITRACTOR PLATE

A key designed to aid in the identification of some or all the families of an order should be based on more than three or four species, hence the following key is not of great value outside the realm of this work. Its purpose is to illustrate the diversity of form and character of the unguitractor plate amongst and within the families of the Hemiptera studied.

1. Empodium emarginate on distal margin (fig. 5) 2
1a. Empodium not emarginate on distal margin (fig. 24) 10
2. Unguitractor plate shaped like an arrowhead (figs. 13, 14) ..... **Aradidae**
2a. Unguitractor plate not shaped like an arrowhead 3
3. Unguitractor shield-shaped (figs. 1, 2, 7) 4
3a. Unguitractor not shield-shaped (fig. 11) 6
4. Distolateral margins of unguitractor coming to a point (fig. 4a) .. **Scutelleridae**
4a. Distolateral margins of unguitractor not coming to a point (fig. 2) 5
5. Empodium rectangulate (figs. 5, 6, 7) ..... **Pentatomidae**
5a. Empodium not rectangulate (figs. 1, 2) ..... **Cydnidae**
6. Unguitractor elongate (fig. 20) ..... **Phymatidae**
6a. Unguitractor not elongate (fig. 24) 7
7. Unguitractor with mesal sclerotized area (fig. 9) 8
7a. Unguitractor without mesal sclerotized area (figs. 21, 22, 23) ..... **Reduviidae**
8. Mesal sclerotized area extending entire length of unguitractor (fig. 16) 9
8a. Mesal sclerotized area not extending entire length of unguitractor ... **Neididae**
9. Lateral areas of the unguitractor lobate (figs. 9, 10) ..... **Coreiidae**
9a. Lateral area of unguitractor not lobate (figs. 17, 18, 19) ..... **Lygaeidae**
10. Empodium bearing parempodia 11
10a. Empodium not bearing parempodia 17
11. Unguitractor spade-shaped (figs. 38, 39) ..... **Notonectidae**
11a. Unguitractor not spade-shaped 12
12. Unguitractor very broad (figs. 32, 34) 13
12a. Unguitractor not very broad (fig. 30) 14
13. Unguitractor subcircular, distolateral sides rounded (fig. 32) ... **Gelastocoridae**
13a. Unguitractor quadrate, distolateral sides coming to a point (fig. 34) ... **Nepidae**
14. Unguitractor rectangular, longer than broad 15
14a. Unguitractor not rectangulate, as wide as, or nearly as wide as long (figs. 30, 31) ..... **Gerridae**
15. Anterior margin of empodium bearing a pair of circular sclerotized areas from which the parempodia arise (fig. 33) ..... **Naucoridae**
15a. Anterior margin of empodium not bearing a pair of circular areas from which parempodia arise (fig. 24) 16
16. Distolateral margins of unguitractor coming to a triangulate point (fig. 24) ..... **Nabidae**
16a. Distolateral margins of unguitractor bending mesad (fig. 25) ..... **Cimicidae**
17. Empodium bearing setae (figs. 35a, 36d, 37b) ..... **Belastomatidae**
17a. Empodium not bearing setae 18
18. Empodium present 19
18a. Empodium absent 23
19. Unguitractor with mesal sclerotized area (figs. 11, 12) ..... **Rhopalidae**
19a. Unguitractor without sclerotized area 20
20. Unguitractor shield-shaped (figs. 3, 26, 27) 21
20a. Unguitractor not shield-shaped (fig. 40) 22
21. Distal margin of unguitractor emarginate (fig. 3) ..... **Scutelleridae**
21a. Distal margin of unguitractor not emarginate (figs. 26, 27d) ..... **Miridae**
22. Unguitractor bowl-shaped, small (fig. 40b) ..... **Corixidae**
22a. Unguitractor not bowl-shaped, large, distolateral margin coming to a point (fig. 37a) ..... **Belostomatidae**
23. Unguitractor shield-shaped, very large (figs. 35a, 36a) ..... **Belostomatidae**
23a. Unguitractor not shield-shaped, not very large (figs. 28, 29) ..... **Miridae**

DISCUSSION

Microscopically, the unguitractor plate does not have a smooth surface. In the Gelastocoridae or Nepidae, for example, the surface is made up of overlapping sclerotized scales that resemble the shape of the placoid scales of the Elasmobranchii and are arranged like the shingles on a roof or the scales on the lepidopterous wing. These scales are in straight rows, not diagonal as in the fish or reptiles. In many other families, such as the Pentatomidae, Miridae, Reduviidae, etc., the scales from transverse plate, *i.e.*, like the ventral transverse plates of many snakes, along the lateral areas or the entire breadth of the unguitractor plate. There is no great difference among these plates or scales of those families examined. Therefore they are not ideal for taxonomic consideration. As a guess, I suggest that their function is to decrease the length of the unguitractor when the tendon is pulling proximad and to give the pretarsus a greater magnitude of flexibility. This presumption is based on the observation that the scales overlap, as for example, the abdominal body segments.

While moving the claws laterad, the unguitractor changes, but its form remains the same. In other words, the dimensions alter, not the habitus. Similarly with the empodium, which is neither drawn from or withdrawn into the unguitractor, although Hayes and Kearns (1934) say that, "There is some evidence to believe that in the type which bears an empodium that the empodium is capable of being extended or retracted within the unguitractor. Some cleared specimens show what appears to be a basal part of the empodium withdrawn into the body of the unguitractor." Their illustration shows a cleared area beneath the empodium as in ***Metrobates hesperus*** (Uhler) (Fig. 31). The reason for the cleared region is the following: The sides and base of the unguitractor are thicker and have more depth than the central portion. The base turns dorsad and the unguitractor tendon is hereto attached (Fig. 4b). Since more light is able to penetrate thinner, rather than thicker materials, the median portion allows more light to penetrate through the ventral clear area. To demonstrate this hypothesis, examine the unguitractor from its dorsum. Here you will see the base perpendicular to the venter, and the sides having width. This may be difficult to see in the smaller insects, but it is quite evident in the Belostomatidae (Fig. 36c).

Contrary to the surmise of Hayes and Kearns (1934) that there is no development of the pretarsus if only one claw is present, there is a pretarsus. Both Griffith (1945) and I have seen the simple pretarsus of the uniclawed corixid pala (Fig. 40a), and in the belostomatid fore tarsi, which has one claw, the unguitractor plate is plainly visible. The primitive condition of the fore pretarsus of the Corixidae, or the more advanced character of the fore pretarsus of Belostomatidae definitely confirms the fact that the pretarsus is present in the single-clawed Anoplura and Mallophaga.

Looking for a distinctive morphological characteristics with which to group the Auchenorhynchous Homoptera into natural categories, H. J. Hansen (1890) discovered the taxonomic value of the pretarsus. He says that the empodium (= arolium) is constructed differently in dif-

ferent families and he described the plate (= unguitractor plate). Reuter (1910) used the characters of the pretarsus as one of the bases for the classification and phylogeny of the Miridae. Jeannel was probably unaware of Reuter's and de Meijere's (1901) works because he first realized the value of the pretarsus for use in taxonomy in 1925. In their paper on the pretarsus of the Coleoptera, Hayes and Kearns (1934) suggested that this structure should be studied in great detail, because it would yield advantageous results. Holway (1935), accepting the challenge, examined representatives of the major orders of insects. and confirmed the suspicions of Hayes and Kearns as to its taxonomic value. Also, he endeavored to show some phylogenetic relationship. The best example offered was the evolution of the Lepidoptera from the Trichoptera. There was a lapse of ten years before anyone again took up the study of the pretarsus as a taxonomic entity. Fennah (1945) studied the same families as Hansen. Fennah's purpose was to test Hansen, but primarily to add to the existing information. His attempt proved successful: for example the Fulgoroidea have been a continually perlexing problem to the Homopterist, but the additional information accumulated by Fennah, aided in settling the affinities of this group.

Other than using the entire pretarsus as an aid in taxonomy, various structures have been used, such as the claws in Coleoptera and the claws and arolia in Miridae. Now another single structure the unguitractor plate, is being considered to see if it exhibits any taxonomic usefulness.

It is impossible to base any phylogeny on one morphological structure, such as the unguitractor. Its form varies so greatly among the families; also the presence of the parempodium is not constant.

However, we are justified in declaring the unguitractor as an excellent implement for identification.

It is self-evident for those familes where two or three or four species were studied, that there is a unifying pattern.

There are several groups of families that bear particular resemblance to each other, The Cydnidae, Scutelleridae, and Pentatomidae resemble each other in that they have a shield-shaped unguitractor. The Coreidae, Corizidae, Neidiae, and Lygaeidae all have a median sclerotized area. The sclerotized area varies in the families. The Reduviidae and Phymatidae are unique in that they have an empodium which is pedicellate proximad, and the distolateral margins branch out into narrow arms. The Nabidae and Cimicidae resemble each other, with respect to the unguitractor, empodium and parempodia. The Gelastocoridae and Nepidae may be confusing since they both have broad unguitractor plates. There is no pretarsus on the forelegs of Naucoridae and Nepidae, therefore the midpretarsi were studied. The mid-legs of Belostomatidae and Corixidae were used in addition to the uniclawed foreleg.

CONCLUSIONS

The unguitractor plate in the Hemiptera can serve as a taxonomic character for classification and identification, and, in conjunction with other characters, can aid in the construction of a phylogenetic scheme.

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INSECTES—QUATRE-VINGTS AGRANDISSEMENTS PRÉCÉDÉS D'UNE INTRODUCTION ET D'UNE TABLE DESCRIPTIVE, by GUY COLAS. Pp. 6, 46 plates, 4to. Librairie des Arts Decoratifs, Paris, 1952.

This is a collection of 80 impressive photographs of greatly enlarged, well-mounted insects. The species are mostly large, conspicuous, rare or unusual, and belong to the following, in decreasing order of number of species of each: Cerambycidae, Heteroptera (mostly Reduviidae), Scarabaeidae, Homoptera, Curculionidae, Chrysomelidae, Elateridae, Lycidae, Mantidae, Blattidae and Carabidae. Unfortunately a few of the specimens have some tarsal claws or antennal segments missing.—J. L. GRESSITT.

CYTOLOGICAL AND HISTOLOGICAL STUDIES IN THE FORMICIDAE

I. Chromosome Morphology and the Problem of Sex Determination

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INTRODUCTION

Modern cytological and histological studies of the Formicidae are relatively few. This appears to be true both in the field of general cytology and chromosome morphology and in comparative studies of internal anatomy and of developmental morphology of the sexes and of the various castes of species having polymorphic workers. Studies of the latter character are of rather far ranging interest in connection with a number of important problems in the biology of ants and of the social Hymenoptera in general. Notable among these are questions of evolution within the group and the general problem of caste determination. Studies of chromosome morphology are of obvious theoretical interest in connection with the mechanism of sex determination in the Formicidae.

Our present knowledge of cytogenetics in the Formicidae is very limited. This is due in part to the unsuitability of ants as experimental material for conventional genetic work. In part, it is due to difficulties involved in studies of their chromosome morphology, both because of special technical problems inherent in the cytology of the group and because of the minuteness of the chromosomes. It is perhaps for these reasons that no modern extended effort seems to have been made to investigate such features of chromosome morphology in the Formicidae as male haploidy or male or female polypoidy.

The purpose of the present series of studies is to reinvestigate various aspects of the cytology and the histology of the Formicidae bearing upon the matter of sex determination, of caste determination, and of developmental morphology within the group. The present paper is concerned with spermatogenesis and oögeneis and chromosome morphology. Later papers will deal with various features of embryology and developmental morphology in general.

HISTORICAL BACKGROUND

As eariler stated, papers dealing with the chromosome morphology of ants are very few in number. Lams (1908) studied the stages of spermatogenesis in the male of *Camponotus herculeanus* Linn. He described the testis cells as being grouped in many clusters around common centers. In each cell, the nucleus was 4–4.5μ in diameter and contained a small amount of chromatin and a conspicuous peripheral nucleolus. At the beginning of cell division, this nucleolus decreased

in size, while the chromatin granules increased in volume and came to form a spireme from which densely staining chromosomes arose. These chromosomes divided into two compact masses. The cell then elongated, and two small centrosomes appeared. One was situated near the periphery of the cell at its drawn-out end. A small bit of the cell was constricted off from the main mass. During this time the nuclear membrane remained intact, but its outline became rather wavy. The chromosomes became more or less distinct in the center of the nuclear mass, with fine fibres between them. A second regular division followed, with each mother cell giving rise to two sperms. Lams stated that he was not able to establish the number of chromosomes. His figures would indicate something of the order of 14 or 15.

Early papers treating the processes of oögenesis in ants deal rather extensively with the cell morphology involved but make little or no reference to nuclear history. One of the earliest descriptions of oögenesis is that of Blochmann (1884, 1886), who studied the process in *Camponotus ligniperdus* Latr. and *Formica fusca* Linn. His attention was centered on the general development of the egg. He particularly emphasized the throwing off of minute bits of nuclear substance, which formed small accessory nuclei.

The first paper dealing specifically with chromosomes in oögenesis is that of Buchner (1918), who worked with *Camponotus* and *Myrmecina*. He described the chromosomes as exceedingly small and numerous, and noted that size differences between cells first appeared in the last oöcyte division, at which time the cell membranes were very difficult to distinguish. The distinction between nurse and egg cells (a matter of size only) first became apparent at the last oöcyte division. The chromosomes were closely massed together deep in the nucleus. With them was associated a slightly larger body, presumably the nucleolus. Buchner gave many details of cell division in the egg, but could not be sure of the last oögonial division and the fate of the resultings cells. Much attention was given to the history of "accessory" nuclei present in the egg. Appearing as minute discrete masses of chromatin around the nucleus, these gradually moved outward, and increased in size. They became invested with a membrane and eventually developed into nuclei which degenerated completly before egg maturation was complete. They showed no evidence of mitosis.

At various times, incidental statements have been made that the number of chromosomes in ants was very large, was about twenty, was sixteen; occasionally chromosomes were shown in figures, but with no mention of them in the text. Seemingly there has been little attempt to study them in detail.

ACKNOWLEDGEMENTS

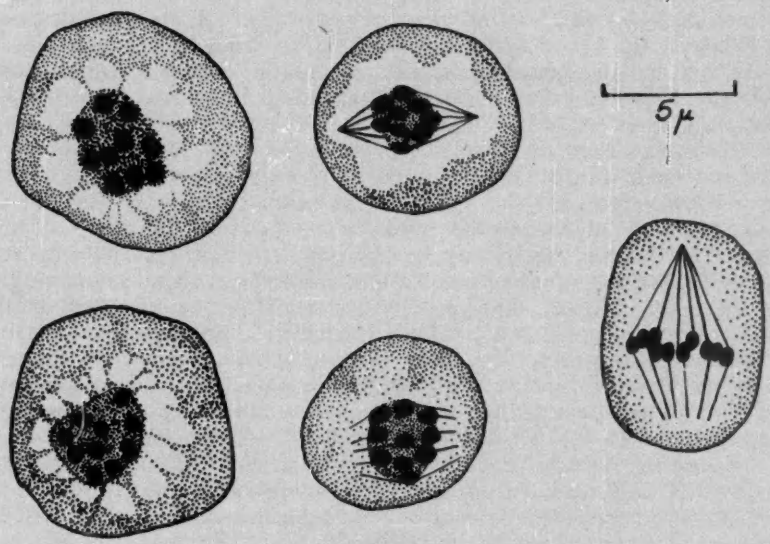
We are greatly indebted to Mr. John Clark of Melbourne, Australia for most kindly sending much invaluable fixed material of *Myrmecia* and *Amblyopone*, to Mr. William Crooks of the Biological Laboratories of Harvard University for large numbers of several species of ants and for a fine supply of wasps used for comparative studies, and to Dr. T. C. Schneirla of the American Museum of Natural History for a fine series of *Eciton* material.

MATERIAL AND METHODS

In order to make the present studies of as general use and as widely comparative as possible, representatives of six subfamilies of ants, Myrmeciinae, Ponerinae, Odontomachinae, Dorylinae, Myrmicinae, and Formicinae, were used. The following species were studied:

Amblyopone australis Erichson
Myrmecia tarsata F. Smith
Stigmatomma pallipes (Haldeman)
Ponera coarctata pennsylvanica Buckley
Paraponera clavata (Emery)
Odontomachus haematoda Linné
Lobopelta elongata (Buckley)
Eciton burchelli Westwood
Eciton hamatum (Fabricius)
Aphaenogaster rudis picea Emery
Myrmica brevinodis Emery
Pheidole hyatti Emery
Pheidole pilifera (Roger)
Crematogaster lineolata (Say)
Camponotus pennsylvanicus (De Geer)
Acanthomyops claviger (Roger)
Lasius alienus americanus Emery
Formica fusca Linné
Formica sanguinea Latreille

The material studied included eggs, larvae, semipupae, pupae and adults (♂, ♀, ♂) of nearly all the species named above.



Text Fig. 1

There seems to be no fixative that will give best results for the ant body as a whole: each organ or tissue presents certain problems. In the present study, it was necessary to find a fixative that could be used directly in the field and would still give reasonably good results. After trying many and varied solutions, it was found that on the whole best results followed fixation in modified Bouin's fluid to which small amounts of detergents had been added. Embedding was done both in paraffin and in celloidin, the latter being almost a necessity with aduits. Many different staining techniques were used. Heidenhain's iron-alum-haematoxylin was found most satisfactory, especially since in this study

attention was centered principally on the nucleus. One striking fact became evident rather early in these studies. The chromosomes, always rather closely aggregated, are surrounded by a thin membrane which retains the stains used about as tenaciously as do the chromosomes. This causes the latter to be partially obscured, particularly in the earlier stages of division. (Text fig. I)

SPERMATOGENESIS

Spermatogenesis normally begins at a relatively early (but variable) stage in the pupal life of the male. Before completion of the pupal period, all potential sperms have reached maturity. The changes leading to maturity, however, do not proceed simultaneously throughout the entire testis.

In the earliest stage of maturation, the spermatogonia appear as quite small uniformly spherical cells, usually lying without any definite evidence of order or association, except that they may be in rather vaguely delimited packets; occasionaly they occur in small botryoidal clusters. Each cell contains a large nucleus in which there is a single distinct nucleolus and a diffuse mass of rather finely distributed chromatin (Plate I, fig. I). Rarely, two nucleoli are present.

As nuclear division begins, the chromatin becomes much more evident. Division takes place simultaneously in many or all of the cells of a single "packet." In some species, these "packets" may contain but a dozen or so cells; in others, however, the number may be of the order of a hundred or more. There is no sequence in which the division-phases of the various "packets" occur with respect to gross structure of the testis. Sometimes a single "packet" at the anterior end of the testis may be the first in which cell division will appear, followed by more or less hapharzard division sequences throughout the testis. Again, division may begin at the posterior end of the testis. Frequently several widely scattered "packets" divide more or less simultaneously. In those cases in which botryoidal clusters occur, the plane of division within the cells is usually entirely at random, and is in no way oriented with the long axis of the cells. Rarely, cases were observed in which the spindles of the dividing nuclei are oriented in a radiating fashion around a common center. (Plate V, fig. 43).

The first indication of division is the accretion of the chromatin to form increasingly distinct elongate twisting masses more or less clearly arranged in a continuous spireme (Plate I, fig. 2; Plate II, figs. 23, 24), which presently breaks up into ten distinct units; these contract to form ten small elliptical chromosomes, quite closely aggregated. At metaphase, a polar view of the chromosomes most frequently shows eight of them forming a somewhat irregular ring within which the other two are found (Plate I, fig. 7). Observed at right angles to this, they appear as a thin oblong in which the individual chromosomes can rarely be made out clearly. These ten chromosomes split longitudinally, the halves moving to opposite poles. Such divisions occur repeatedly until the gonad contains an immense number of small cells showing some difference in size but none in appearance.

The final divisions and the subsequent transformations to mature sperms take place in groups also. The last two divisions which occur

are meiotic. The first of these is equational, with ten groups of minute bodies obviously doubled but so very small that exact details can scarcely be seen (Plate II, figs. 17, 25, 41; Plate V, fig. 27). The second is reductional, with five small chromosomes then found in each of the resulting nuclei (Plate I, fig. 10; Plate II, fig. 26; Plate V, figs. 44, 45). Even before the identity of the five chromosomes is lost in their ultimate fusing, the first indication of the formation of the future tail of the sperm appears. It closely resembles a half spindle in appearance and could very easily be confused with this, even having at its tip a minute body like a centrosome. Subsequent events show the true nature of this structure (Plate I, figs. 9, 11).

The five chromosomes quickly gather to form a spherical mass so densely staining that no details can be discerned; at the same time the conical tail initial elongates considerably, losing its apical granule but showing no observable structural changes (Plate I, fig. 17). Presently the spherical head elongates slightly, the chromatin now lying in a mass covering the greater part of the surface, but appearing rather comma-shaped when seen from one side. At this time, if not earlier, a faint very delicate line appears, extending the entire length of the now very long conical tail portion. The head portion continues to lengthen, soon forming a long, cylindrical, much-contorted head, which stains uniformly black with nuclear stains (e.g. haematoxylin), while the conical portion of the very long tail begins to disappear, leaving presently only the long thin lash surrounded by a very thin zone of colorless and apparently structureless substance. The maturation of the sperm is now complete. The head portion is very long and slender, with the forward end somewhat tapered to a conical apex, and the posterior end narrowed rather more bluntly to join the very slender tail, which is many times as long as the head (Plate I, fig. 24). In cross-section these heads are ovoid (Plate I, fig. 27).

The mature sperms in nearly all the species studied occur in large compact "packets" in which most are oriented in the same direction (Plate I, fig. 25). In many bundles, however, there will appear a few sperms, seldom more than half a dozen, oriented oppositely from the majority. The bundles themselves seem to be oriented more or less at random, at least in most of the species studied here.

Very occasionally there are found isolated large cells in the body of the testis. They appear to occupy positions where the thin sheaths bounding individual "packets" of sperms form "corners" by contact. None of these were seen to divide, nor do they seem to persist in a testis containing mature sperms. Within the spermatheca of a fertilized queen, the sperms are massed into a dense tangle, or not infrequently into several such masses.

The mature sperms squeezed from an adult male into a suitable liquid medium by moderately gentle pressure exhibit a vigorous lashing motion, often without very much forward progress. Perhaps because of the pressure exerted and the unnaturalness of the treatment, the tails often become separated from their heads, but still lash vigorously for a time.

OÖGENESIS

Throughout the pupal life of the female (queen) ant, divisions in ovariole tissue may be frequently observed. Early divisions show the usual diploid number of ten chromosomes (Plate V, fig. 11). Polyploid cells, however, are occasionally observed, nearly all in the peripheral regions of the ovariole; in these there are twenty or rarely thirty chromosomes (Plate V, fig. 15). The component cells of the ovariole tissue show no noteworthy difference among themselves except such in size or shape as may be caused by mutual pressure. The axes of the spindles of dividing cells are oriented at random (Plate III, fig. 8).

Toward the end of the pupal period, the processes foreshadowing the formation of the egg begin. Small groups of cells near the upper end of the ovariole simultaneously begin dividing; in each cell, there are ten chromosomes each appearing distinctly double (Plate V, fig. 18). At a point slightly lower in the ovariole, a second division may be seen, in which the chromosome complement is five (Plate III, figs. 15, 17; Plate IV, figs. 25, 26, 27). Details of the process have not been clearly observed as yet. It is noteworthy that these divisions have been seen only very rarely, suggesting that they may take place very rapidly.

Following the meiotic divisions, a series of obvious and conspicuous changes takes place. The maturing eggs enlarge greatly and presently become enclosed in a unicellular layer of peripheral cells. The egg nucleus enlarges also, the chromatin mass within it appearing dense and very irregular. No indication of nuclear division within the egg has been detected at this stage. Eventually, as the maturing egg moves down the oviduct, the nurse cells disappear and the egg is ready for oviposition, with or without previous fertilization.

CHROMOSOME MORPHOLOGY

The freshly laid ant egg is thus uninucleate, as Reith (1935) has pointed out. If unfertilized, (and hence, presumably, destined to be male producing) it will contain the haploid chromosome number of five. If fertilized it will be diploid.

Detection of the first nuclear division of the egg presents certain practical difficulties, arising in part from the structure of the egg itself, especially the presence of numerous globules of substances showing staining reactions often precisely similar to the nucleus, and in part from the rapidity with which these first divisions must occur in newly-laid eggs. Examination of sections of several hundred eggs laid by artificially dealated virgin queens, mainly of the genus *Pheidole*, has revealed two instances of what seem to be first nuclear divisions. In one of these (Plate IV, fig. 28), where the egg was fixed almost immediately after deposition, division had proceeded to what appears to be the beginning of anaphase, the five chromosome pairs just beginning to separate. In the second case (Plate IV, fig. 5), division was more advanced, and appears to be in late anaphase. Here there are two sets of five chromosomes, one sharply clear, the other beneath this slightly to one side, its five chromosomes (not shown in the figure) being in part hidden beneath those above. Nuclear divisions following the

first one in the egg always show ten chromosomes. It thus appears that autodiploidization in developing males occurs at a very early stage of the developing egg—probably in the first two or three nuclear divisions.

This chromosome number of ten is found invariably during the early development of the embryo. (Plate IV, figs. 2, 3, 4, 6, 7, 10). With the formation of a complete cell layer at or within the egg surface, polyploid nuclei first appear. In these cells there may be twenty, thirty, or very rarely forty chromosomes. Throughout embryonic development, and in larval and pupal life, similar polyploid nuclei may be observed in many tissues and organs, always in single cells or in small groups of two or three cells. (Plate IV, figs. 13, 15). These have been noted in the epidermis, the supra-and suboesophageal ganglia (Plate III, fig. 25b; Plate V, fig. 12, 13, 14), the developing gonads (Plate IX, fig. 21) and locally in the alimentary system.

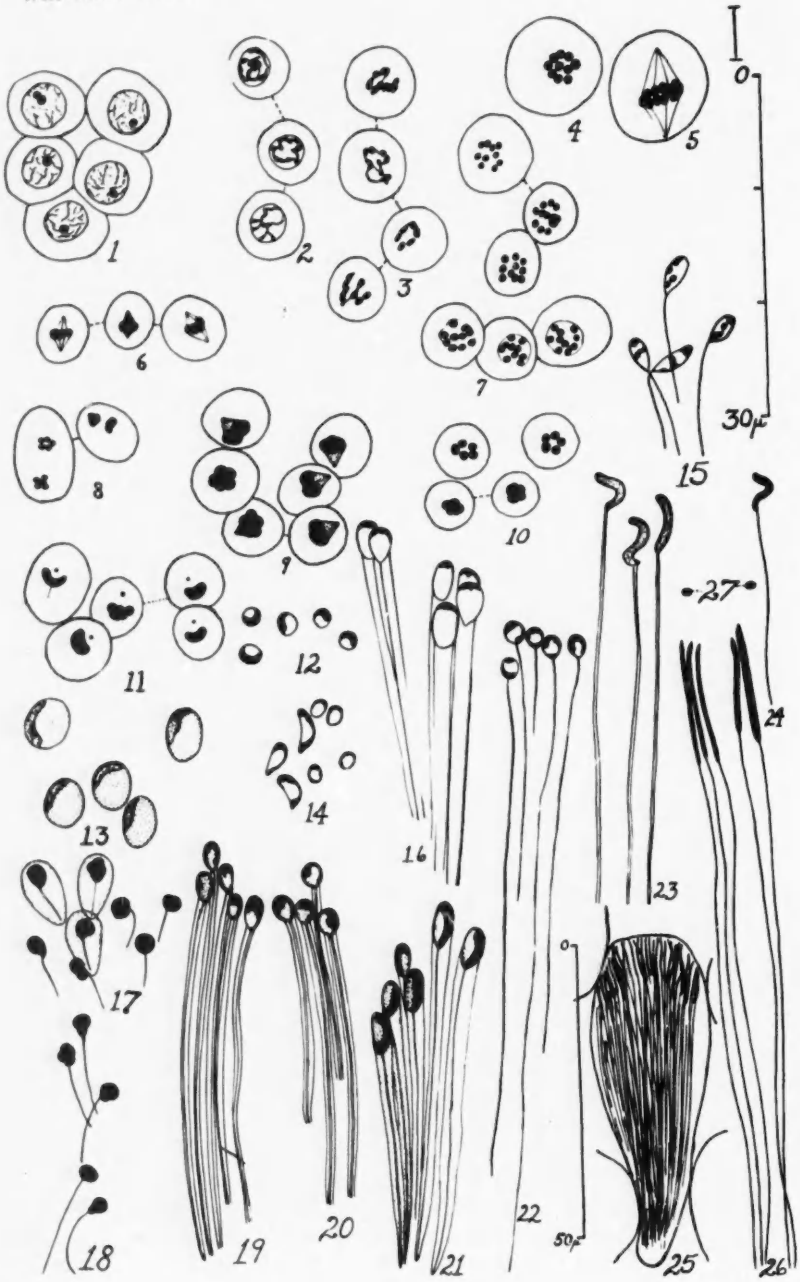
It thus seems clear that, as some other workers have noted, polyploid cells are by no means uncommon in developing embryos or larvae of the Formicidae, but that the diploid number, ten, is the rule.

SUMMARY AND CONCLUSIONS

As a result of very extensive cytological work on various developmental stages in the Formicidae, extending over ten years and including nineteen species of six subfamilies, ranging from the most primitive to the most highly specialized of the group, the following conclusions seem possible:

1. The haploid chromosome number throughout the group is constant and is five.
2. Autodiploidization occurs very early in the development of the unfertilized (male-producing) egg, so that the diploid number is restored very shortly after oviposition. Male tissue is thus cytologically diploid, like that of females, but is of course genetically haploid.
3. Somatic polyploidy is very frequent, and may run up to considerable duplication—occasionally up to octoploidy.
4. Meiosis in spermatogenesis follows a pattern very usual in the social Hymenoptera. The first meiotic division is equational, the second reductional; four functional sperms come from each primary spermatocyte.

PLATE I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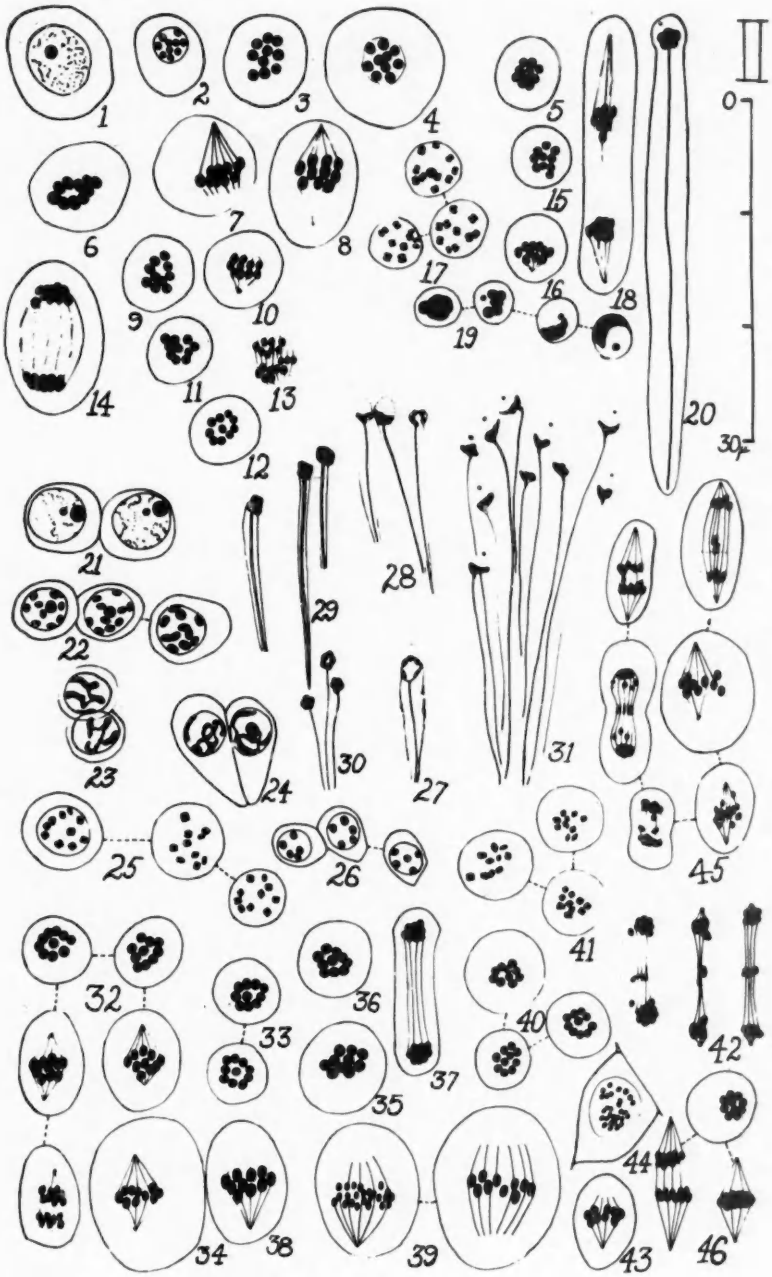
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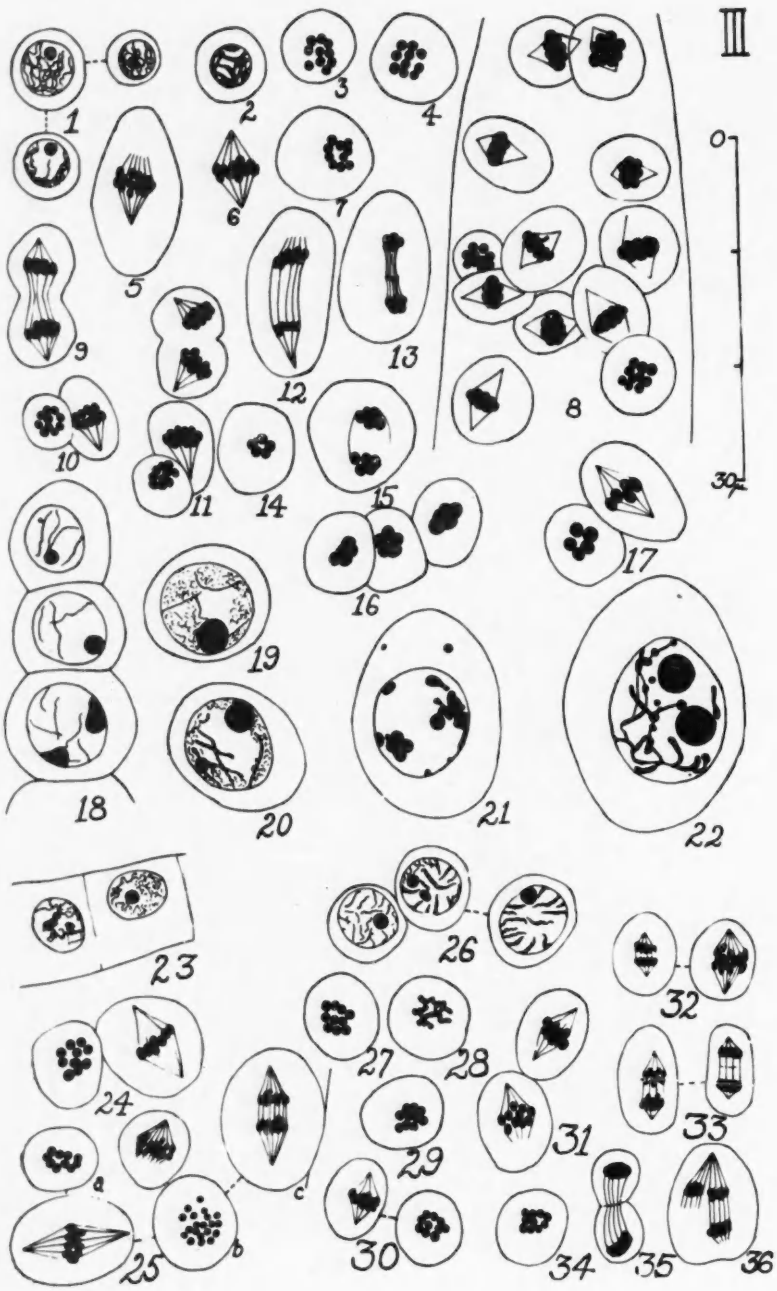
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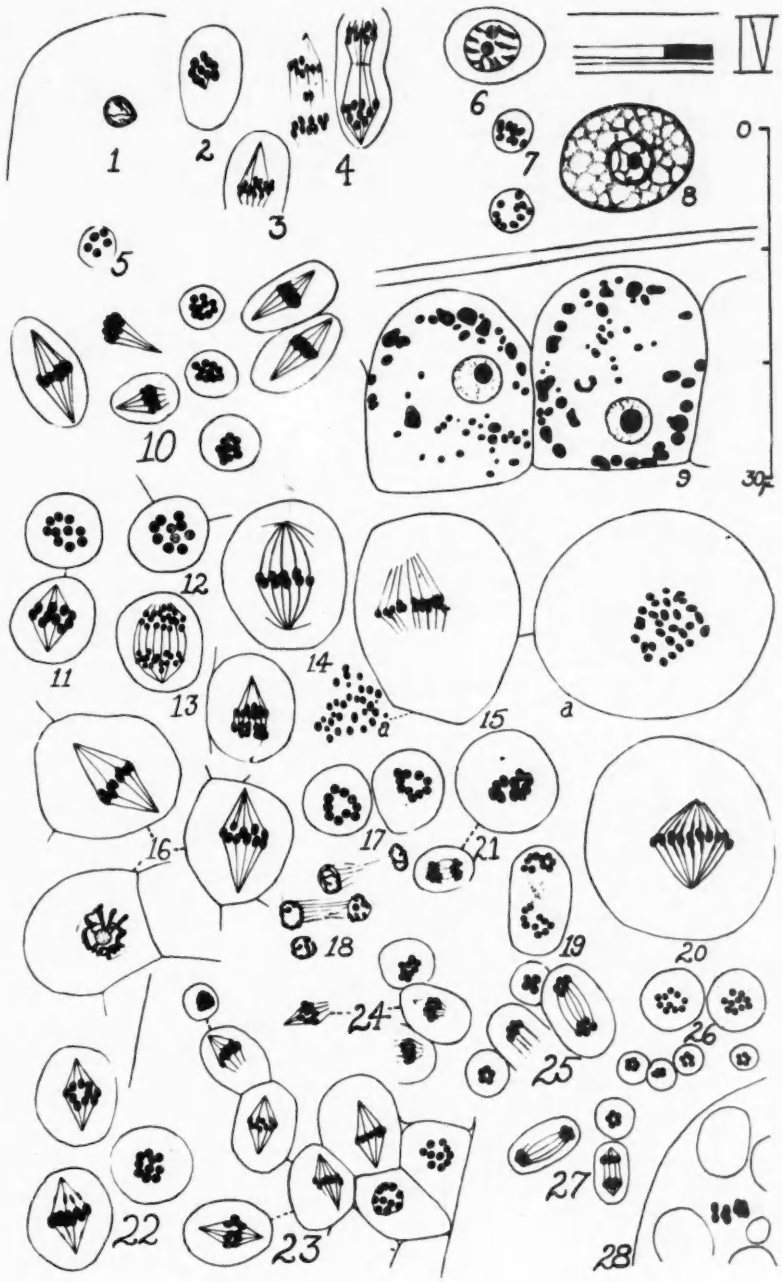
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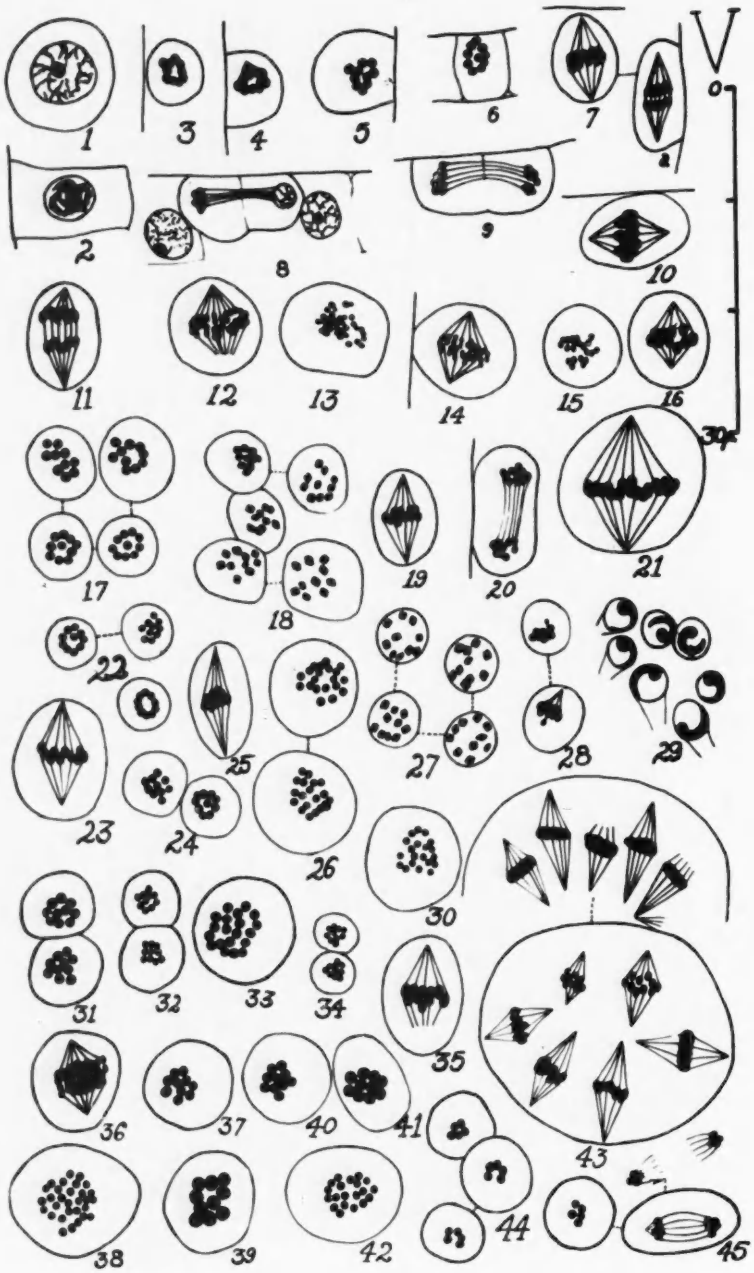
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DESCRIPTION OF PLATES

All figures have been drawn with the aid of a camera lucida. With one exception the scale of magnification is uniform throughout, and is indicated by the 30μ scale on each plate. The one exception occurs in Plate I, fig. 25.

Nearly all figures are from sections cut 5μ thick, and are selected only when the entire cell nucleus is present in the section. In a few instances sections 8μ or 10μ thick were used. In rare cases, where the cell was very large (*e.g.*, Plate IV, fig. 20), the figures was necessarily "constructed" from the component parts found in three successive sections.

EXPLANATION OF PLATES

PLATE I

Lasius alienus americanus Emery; from male pupae. FIG. 1. A group of five cells, showing the nuclei in the normal interphase condition. FIG. 2. A group of three cells with their nuclei in rather early stages of prophase. FIG. 3. Four cells in which division of the nuclei is rather more advanced than in those of fig. 2. FIG. 4. A cell from the epidermis of the head, showing the ten chromosomes. FIG. 5. A cell from the cortex of the brain, showing the ten chromosomes. FIG. 6. Sex cells showing the second meiotic division, with five chromosomes present. FIG. 7. A group of six dividing cells from the testis. In each, ten chromosomes are distinct. In the lower three the nuclear membrane still remains discernible; in one of the upper three a vestige of the nucleolus is still present. FIG. 8. Two cells in late stages of the second meiotic division. FIG. 9. The beginning of sperm formation. The conical structure present in each of these cells is not a spindle. FIG. 10. A group of four sex cells after reduction division, each containing five chromosomes. FIGS. 11–23. Various stages in the formation of the sperm. FIG. 24. A nearly mature sperm, but with the head still very much twisted. FIG. 25. A "packet" of sperms as they occur in the testis. Note the two sperms reversed in position. (The scale of this drawing is placed beside it.) FIG. 26. Five mature sperms. The total length of the tail is much greater than shown. The mature sperms of all species of ants studied here are approximately identical to these in shape. FIG. 27. Transverse sections of the heads of two sperms.

PLATE II

FIGS. 1–20. *Lobopelta elongata* (Buckley); from pupae. 1. The appearance of cells in interphase, showing the conspicuous nucleus, usually single, and the very scanty chromatin. 2. A cell from the wall of an ovariole. The nuclear membrane is still present, but division of the nucleus has reached late prophase, with ten small but distinct chromosomes. 3. A cell from the central portion of an ovariole, with no nuclear membrane and ten large and distinct chromosomes. In this region of the ovariole, there is a vague suggestion that the cells occur in groups of four. 4. A cell from the "buccal" gland of a pupa, showing ten chromosomes. 5. A cell from the central part of a testis, with the ten chromosomes rather closely aggregated (still easily counted). 6, 7. Two cells from the wall of the oviduct, each showing quite clearly the ten chromosomes. 8. A cell from the "buccal" gland, cut at a different angle than that in fig. 4. From a male pupa. 9, 10. Two cells from the epidermis of a male pupa, each containing ten chromosomes. 11. A cell from the center of the testis, the ten chromosomes more irregularly arranged than those in fig. 5. 12. Another cell from the testis, showing a very uniform arrangement of cells in metaphase. 13. A nucleus of a dividing testis cell, with ten pairs of chromosomes (in the upper set some have been cut off in the adjoining section). 14. A cell from the developing salivary gland (or closely associated tissue near the duct) of a worker pupa, showing ten pairs of chromosomes in early telophase. 15, 16. Two cells from the center of the testis, each with ten chromosomes. 17. Three cells in the first meiotic division, occurring in the body of the testis. 18. A very elongate cell from the interstitial tissue of a testis. The nucleus shows ten pairs of chromosomes in mid-anaphase. 19. Four cells just at the inception of sperm formation. In some there is an indication that there are five chrosomes, still rather vaguely outlined. 20. A well advanced stage in sperm formation; but still with the five chromosomes suggested as present in the developing head.

FIGS. 21–31. *Camponotus herculeanus pennsylvanicus* De Geer; from pupae. 21. Two cells from the testis, the nuclei in interphase. The presence of one conspicuous large nucleous and one very much smaller one is of rather usual occurrence here. 22. Three testis cells in very late prophase, the ten chromosomes being already definitive in each nucleus and the nucleolus vanishing. 23, 24. Cells from the testis, the nucleus being in mid prophase condition, spireme evident. 25. Three cells in the first meiotic division, there being ten chromosomes in each. These cells are from the testis. 26. Three cells from the testis, with the reduced number of chromosomes, five, present in each. 27–30. Stages in the development of the sperms. 31. Sperms approaching maturity. These occurred near the "lower" end of the testis.

FIGS. 32–44. *Odontomachus hematoda* Linné. 32. Five cells from a well advanced embryo. 33. Two cells from larval ovarioles. 34. A cell from an embryo at approximately a 100-cell stage. Every cell showed ten chromosomes when dividing, as in the one figured. 35. A cell from the cortex of the brain of a larva, the ten chromosomes of which are rather large. 36. A cell from a larval ovariole, with ten chromosomes present. 37. A cell from the cortex of the brain, the nucleus in early telophase, with ten chromosomes indicated at each pole, though so closely aggregated that positive counting is not possible. 38. A cell from an ovariole of a very young larva, showing ten quite large chromosomes. 39. Two large cells from near the surface of the cortex of the brain. In one there are clearly more than ten pairs of chromosomes, though the exact number is not determinable; in the other the ten chromosomes in metaphase are sharply distinct. 40. Three cells from the testis of a male pupa, showing the different cell-sizes occurring here, and the ten chromosomes in each and their arrangement. 41. Three cells in the first meiotic division. 42. Three dividing nuclei from a larva (apparently a queen), showing abnormal separation of the chromosomes, some remaining at the equatorial plate and some migrating away from the others. Such irregularities appear to be not infrequent in some individuals and completely lacking in others. 43. A cell from the epidermis of a very small (young) larva, with ten chromosomes present in metaphase. 44. A cell from the epidermis of a well-advanced embryo. The cell is from the anterior portion of the embryo, and contains about thirty minute chromosomes.

FIGS. 45, 46. *Crematogaster lineolata* (Say). 45. Six cells containing dividing nuclei in which conspicuous irregularities occur, lagging chromosomes being especially evident. Such irregularities seem to occur only in certain individuals. The six cells shown here are all from the brain cortex in young larvae. 46. Three normally dividing cells, showing ten chromosomes.

PLATE III

FIGS. 1–22. *Lasius niger* subsp. *alienus* var. *americanus* Emery; from queen pupae. 1. Three cells from the uppermost (apical) portion of the ovarioles of a queen pupa. All are in the interphase state or in very early prophase. 2. A cell in the ovariole, in prophase of division, with ten prochromosomes present, and the nucleolus. 3–7. All cells in the metaphase or early anaphase of division, each having ten chromosomes (ten pairs in fig. 5), with figures 3, 4, and 7 showing irregularity of arrangement of the chromosomes at the metaphase. 8. A longitudinal section of a portion of an ovariole, showing the rather irregular orientation of the spindles; in two nuclei these are perpendicular to the plane of the section, with the ten chromosomes present in all the nuclei being in these two very obvious. In the regions immediately above and below this portion of the ovariole almost no dividing nuclei occurred. 9. A cell, in an ovariole, showing pronounced constriction already present in mid-anaphase of division. 10, 11. Two groups of cells from ovarioles, showing ten chromosomes in each cell. In the upper part of fig. 11 are two cells in which no trace of a separating wall could be seen; nor could the other halves of the two spindles be seen except very close to the chromosomes, and there very faintly. 12. Mid-anaphase of a cell in the ovariole, showing ten chromosomes. 13, 15. Two cells from an ovariole, in which there are five chromosomes at each of the poles, these chromosomes so closely massed in fig. 13 that counting is difficult. Apparently this is the second meiotic division, more clearly shown in fig. 15. 14, 16. Cells from an ovariole, showing five chromosomes very clearly. 17. A pair of adjacent cells in an ovariole, both in metaphase, the one cut parallel and the other perpendicular to the axis of the spindle. 18. A

row of cells in an ovariole (in this case there were four, most of the lowest one being in an adjoining section), after enlargement has become quite pronounced and the nuclear contents scanty. 19. The first positive appearance of an egg cell. Many of those which begin to enlarge, as in fig. 18, do not go on to become eggs, but appear to be absorbed. 20–22. The enlarging egg, as it occurs far up in the ovariole, before any layer of peripheral cells has been formed. In no two eggs is the chromatin content qualitatively alike, though there is always present as a conspicuous feature one to three large nucleoli.

FIGS. 23–25. *Odontomachus hematoda* Linné. 23. Two cells from an embryo in an egg in which the cells form a nearly uniform layer over the surface of the yolk, except for a narrow band of rather minute cells, the primitive streak. 24. Two adjoining cells in the same (metaphase) phase of division, showing ten chromosomes. 25. Five dividing cells from a later stage in embryonic development. a. Three cells from the anterior end, showing ten chromosomes (or pairs of chromosomes) in each. b. An epidermal cell from the anterior part of the embryo, with twenty chromosomes. c. Another epidermal cell, in mid-anaphase, with ten pairs of chromosomes. The line more or less tangent at the right indicates the surface of the embryo.

FIGS. 26–36. *Acanthomyops claviger* (Roger), from rather advanced queen pupae. 26. Three cells from the ovarioles, near the apical end, where differentiation of the eggs has not yet occurred. Two of these cells are in early prophase. 27. A cell from the same region in metaphase, with ten chromosomes. 28. A cell from the same region, with the nucleus in mid-prophase. 29–34. Cells from various parts of the upper portion of ovarioles, all showing ten chromosomes, or chromosome pairs. 35. A cell near the end of division, the chromosome masses so densely aggregated that counting is impossible. Such dense aggregations are not infrequent in ant cells. 36. An example of a condition apparently occurring very rarely in ants, in which there appear to be two complete spindles in a single cell.

PLATE IV

FIGS. 1–5. *Pheidole;* from eggs laid by virgin queens. 1. A single nucleus together with a portion of the egg membrane from an egg in which there are already about thirty free nuclei. There is a suggestion that this nucleus is in an early prophase stage of division. 2. A dividing cell, showing clearly ten chromosomes, from the general epidermal layer in an egg in which little differentiation of cells is apparent. 3. A dividing cell, in early anaphase, showing ten pairs of chromosomes. This cell is in the general mass of small cells forming the first clear indication of the developing embryo. 4. Two dividing cells from an embryo showing clearly the presence of eleven segments. The cells are from one of the nerve ganglia, which as yet show no differentiation of tissue. Ten pairs of chromosomes are present in each cell. In that at the left two chromosomes remain in the equatorial region; apparently they should have moved with the upper set, where only eight are present. 5. This is from an egg which had been laid only a few hours. There are two groups each of five chromosomes close together and one above the other as the sections were cut. The nuclear membrane is very thin.

FIGS. 6–9. *Myrmecia tarsata* F. Smith; from eggs. 6. An early prophase stage of a nucleus from an egg in which most of the nuclei occur near the surface and in which the beginnings of cell-walls are apparent around some of the nuclei. 7. Two dividing nuclei in metaphase, showing in each ten chromosomes. These are from an egg containing about 350 nuclei somewhat irregularly distributed. 8. A single cell together with (above it) the egg membrane surrounding the egg. The outer membrane, the chorion, has three distinct layers: an outer rather thick one appearing quite structureless and staining faintly blue with haemetoxylin; a middle one, also quite thick, and studded with very fine densely massed radiating pores, the whole staining almost black with haematoxylin; and an inner very thin structureless membrane separating the other two from the thin structureless vitelline membrane. 9. Two of the large cells, together with a portion of the vitalline membrane, from an egg with early embryo, represented only as a streak of rather small cells. 10. *Paraponera clavata* (Emery). Eight dividing nuclei from an early undifferentiated embryo.

FIGS. 11–21. *Formica fusca* Linné. 11. Two dividing nuclei from the epidermis of a very young embryo, upper from the anterior region; lower from the mid-ventral region of the embryo. 12. A dividing cell, with ten chromosomes

obvious, near the posterior pole, at the junction of two segments. 13. A cell from the epidermis of the first thoracic segment of a very young embryo. It contains 20 pairs of chromosomes in rather late anaphase. 14. A large cell from the cortex of the "brain." There are ten chromosomes present. 15, 15a. Cells from a very young embryo. In each of the cells shown there are about thirty chromosomes, though when viewed laterally (as in fig. 15) it is impossible to count them accurately. 16. Three cells from a very early embryo of an egg laid by a worker. In the lower cell the nucleus is in late prophase; in the other two it is in metaphase, with ten chromosomes present in each. 17. Two dividing cells from the body of the testis at the stage when this organ first becomes clearly recognizable. In each the ten chromosomes are distinct. 18. A group of five nuclei occurring within the testis. 19. A dividing cell, in very late anaphase, from the epidermis of a very early embryo in a worker-laid egg. Ten pairs of chromosomes are clearly present. 20. One of the very large cells typical in early egg development, before morphological cell differentiation begins. 21. Two dividing cells, one very small and one rather large, occurring rather close together in the mid-portion of the same testis. In each there are ten pairs of chromosomes, very large in the large cell and very minute in the small cell.

FIGS. 22–27. *Eciton burchellii* Westwood. 22. Three cells from the ovariole of a very advanced worker larva. In each, ten chromosomes are present. 23. A group of dividing nuclei from the upper (apical) portion of an ovariole of a queen pupa, showing the rather irregular orientation of the spindles and the presence of ten chromosomes in each cell. 24. A group of four cells (nucleus only in one at left) from the ovariole of another queen pupa, again showing ten chromosomes in each. 25, 27. Two groups of dividing cells from the apical portion of the ovarioles of queen pupae showing the second meiotic division, with five chromosomes in late anaphase or telophase. 26. Two groups of cells from the upper portion of an ovariole of a queen pupa; the upper two cells contain ten chromosomes each; the lower four, occurring very near the upper two, contain five chromosomes each.

FIG. 28. *Pheidole hyatti* Emery. This egg was fixed very soon after it was laid. It has but a single nucleus, this appearing to be in very early prophase of division, with probably five pairs of chromosomes present.

PLATE V

Stigmatomma pallipes (Haldeman). FIGS. 1–18. From queen pupae. 1. A typical cell at interphase; such are found in nearly all tissues except the wall of the midgut, the salivary gland, and the muscle tissues 2. A cell about the middle of prophase from general epidermal tissue. 3. Dividing cell from the epidermis of a developing appendage; the section shows the ten chromosomes in metaphase plate. 4. A similar cell from a later stage in the development of the pupa; from the epidermis of a leg. The plane of the section is slightly diagonal to the plane of the metaphase plate. 5. Similar to fig. 3, but from the epidermis of the dorsal region of the developing thorax. 6. A dividing cell (metaphase plate, with ten chromosomes) from the wing bud. 7. A dividing cell from the central part of a developing leg (tissues as yet not positively determinable but probably muscle). The plane of the spindle is slightly diagonal to that of the section, so that all ten chromosomes are visible. 7a. A similar cell from the central portion of the developing antenna. Here division is in early anaphase, with ten pairs of chromosomes present, but not too clearly shown because of the angle of the section. 8, 9. Two dividing cells from the epidermal tissue (from the head). In fig. 8 a not infrequently observed state is shown in which one of the resulting cells is far in advance of the other. In fig. 9 the ten pairs of chromosomes are fairly distinct. 10. A dividing cell, with ten chromosomes present, from the inner part of a developing mouth part, as yet not determinable. 11. A cell from the wall of an ovariole, with ten chromosomes present in the upper set. 12. A rather large cell from the region of the mouth part anlagen. It is in early anaphase, with twenty pairs of chromosomes present. 13. A section of a cell similarly located, in another pupa, with about thirty chromosomes present. 14. A similarly large cell from the epidermis. Probably twenty pairs of chromosomes are present. 15. A cell from the wall of an ovariole with twenty chromosomes. 16. A dividing cell from the inner tissue of a mouth part, showing ten chromosomes. 17. A group of four cells from the center of the apical portion of

an ovariole, all four showing ten chromosomes present in the metaphase plate. 18. A group of five cells in the first meiotic division, the ten chromosomes clearly distinct. From the upper (apical) portion of the ovariole.

FIGS. 19–22. From worker pupae. 19. A dividing cell, in metaphase, from the body epidermis of an early pupa. 20. A cell, near the end of anaphase, from the inner oesophageal wall of a rather mature pupa. Ten chromosomes are clearly present in each group. 21. A large cell from the wall of the intestine. Twenty chrosomes are present here. 22. Two dividing cells from pupal tissues near the posterior pole.

FIGS. 23–29. From male pupae. 23. Cell in wall of buccal gland, showing ten chromosomes in metaphase. 24. Two dividing cells from central portion of testis, each showing ten chromosomes. 25. A dividing cell, in metaphase, from the outer wall of the testis, also with ten chromosomes. 26. Two large cells from the buccal gland, each showing twenty chromosomes. 27. Four cells from the "body" of the testis, each in the first meiotic division with the ten chromosomes clearly present. 28. Two dividing cells from the central part of a testis, showing small satellite-like bodies attached to the chromosome group by a slender thread. Such cases are to be observed in ant cells only infrequently. 29. A rather frequently found stage in sperm formation.

Formica sanguinea Latreille. 30. A dividing cell found in the epidermis of the developing leg-bud of a young larva. It has twenty chromosomes. Such cells seem always to occur singly or in groups of two to four cells. 31, 32, 34. Three pairs of dividing cells, all in metaphase, from the testis of a young larva. In each there are ten chromosomes, all of quite uniform size in a single cell, but noticeably unequal in the three groups. 33. A very large cell from the same region in the testis as the previous ones. This cell shows twenty chromosomes. 35. A cell from the cortex of the brain, showing ten chromosomes. Dividing cells such as this one are frequently to be observed in the cortex of any ganglion of the nervous system. 36. A cell from the proventriculus of a large larva, showing twenty pairs of chromosomes in early anaphase. 37. A cell from the central portion of the ovariole of a worker pupa. 38. A cell from the inner wall of the proventriculus of a worker pupa. In it there are thirty chromosomes in metaphase. 39. A dividing cell from the central portion of one of the developing mouth parts of a worker pupa. In it each of the ten chromosomes is distinctly larger than usual. 40, 41. Two dividing cells from the acid gland of a worker pupa, showing in each ten chromosomes. 42. A large cell from the epidermis of one of the developing legs of a worker pupa. In it there are twenty chromosomes. 43. Transverse sections of a developing testis in an early pupa, showing a radial orientation of the dividing cells. Such regular arrangements are distinctly rare in this and apparently in most species of ants. 44. Three cells, each with five chromosomes, from the testis of a pupa. 45. Three cells in late anaphase of the second meiotic division, each showing five chromosomes. The cell at the left, very similar to those in fig. 44, actually showed faintly the same spindle structure as is shown in the other two cells. Those of fig. 44 show none and are associated with other cells in which the chromosomes are aggregated into a single mass.

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TRANSFER OF RADIOACTIVITY FROM WORKER TO DRONE HONEY BEES AFTER INGESTION OF RADIOACTIVE SUCROSE

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Little attention has been given to whether the males of social insects are independent of the workers or partly or wholly dependent on them. Schwartz (1948) does not discuss the question in his monograph on the stingless bees (Meliponidae). The drones of stingless bees in Costa Rica, according to Orlando Munoz B. (personal communication), are not seen on flowers. P. Nogueira-Neto, an authority on the stingless bee in Brazil, has captured a few male bees on flowers. He says (personal communication), "I suspect that males [stingless bees] may feed or be fed (it is not known) in the hive, but I believe that they also feed on flowers." Kerr (1951) states that drones of some species of stingless bees leave their nest when adult and do not return to it. The implication is that they can support themselves by getting food from flowers. He thinks that males of *Melipona quadrifasciata* Lep. cover themselves with pollen, thus enabling themselves to enter any colony.

Apparently, information is entirely lacking as to the care of drones of stingless bees within the colony. According to Plath (1934), the males of some species of *Bombus* take nectar directly from the flowers. Sladen (1912) states that bumble bee drones leave the nest as soon as they can fly and thereafter maintain themselves. The males of *Vespula* take nectar from flowers, and males of *Polistes* eat food secreted by the larvae in their nests (Michener and Michener, 1951). Males of Epiponinae get food from the foraging female wasps, according to Wheeler (1923). Haskins (1939) says that male ants do not usually provide food for themselves but are fed by the workers. After they leave the nest, they may find a little pollen or nectar, but they soon die. D. M. Vowles (Anonymous, 1952) thinks that food exchange between worker ants is of a parental nature, and that the mouth parts and the antennae of donor and recipient of food are used.

Some experimental work on the flight of drone honey bees, *Apis mellifera* L., in the field (Oertel, unpublished) indicates that drones are not likely to fly more than a mile or two from their hive. If they were to fly farther, they would probably starve to death before they

[1]In cooperation with Louisiana State University.

[2]Work performed under Contract No. AT-(40-1)-1083 for the Atomic Energy Commission.

could return to the hive, because they do not take nectar from flowers and the honey stomachs of dissected drones seem to be only partly full. We have no information on how drones obtain food when they are in the hive. Honey, which consists chiefly of dextrose and levulose, is available in the normal colony. Perhaps the drones help themselves to honey or are fed by workers, or partly by both means.

The life of caged drones is considerably extended when worker bees are in cages with them. For example, caged drones lived less than 1 day when given no food; they lived 3 to 3.5 days when sucrose sirup was available; and they lived 5.3 to 6.5 days with sirup available and worker bees in the cages with them. Perhaps the presence of worker bees with the drones establishes a society which in itself can extend their lives. Perhaps the workers groom the drones or feed them some glandular secretion or regurgitated sirup. The experiment reported here was conducted to learn whether the workers could and would pass sirup containing radioactive carbon (C^{14} labeled sucrose) to drones through a screened partition.

METHODS

Ten drones and 20 worker honey bees were placed in a 3 by 3 by 1½ inches wire cage which was divided into two parts by screen wire 8 meshes to the inch. The drones were in one part where they had access to a 50-percent nonradioactive sucrose sirup, and the workers in the other where they had access to a similar sirup that contained C^{14} labeled sucrose. The sucrose had a specific activity of 0.5 microcurie per milligram, and enough was used to produce a sirup with an activity of 10 microcuries per milliliter. After a 3-hour feeding period, during which the workers consumed about 1 ml. of radioactive sirup, all the bees were removed from the cage and killed. The legs, antennae, and mouth parts of the drones were then removed and discarded, since there was a chance that these organs could have had accidental contact with the workers' mouth parts. The drones and the workers were heated at 120° C. for 2 days, ground in a mortar, and placed in a desiccator until the radioactivity counts could be made.

In order to compare the activity counts of the drones with those of the workers it was necessary to determine specific activity (activity per unit weight) rather than total activity. Drone honey bees weigh nearly twice as much as the workers. To measure specific activity, a layer of honey bee sample of sufficient thickness to absorb the radiation from lower layers was placed on a pan. The counting of samples prepared by this method gives a measure of the concentration of the radioisotope, for the particles entering the counting tube are from equal volumes of sample if the surface areas are the same. An increase in the thickness of the layer does not result in an increased count. Each sample was in excess of the minimum 25 mg./cm². required for an infinitely thick layer when C^{14} is used.

Radioactivity counts were made from samples placed on shelf No. 2 of a vertical lead shield (No. 56, Technical Associates) in which was mounted a Geiger tube (Amperex 200NB, Series 1591 I) with an end-window thickness of approximately 1.4 mg./cm². Counts were recorded on a decimal scaler (Berkeley Model 1000 B, Series 221).

RESULTS

Net radioactivity counts of the drone bees totaled 91,753 and that of worker bees 753,573. After correction for time and background the net count per minute was 456 for drones and 9,420 for workers of equal sample weight. Control drones not exposed to C^{14} did not show radioactivity. The exposed drones exhibited approximately one-twentieth of the activity of the exposed workers. Thus a considerable quantity of the radioactivity contained in the sugar sirup ingested by the workers had been transferred in some form to the drones.

DISCUSSION

Although sirup was available to the drones in their side of the cage, they took radioactive material (probably sirup) from the workers through the screen. It can be inferred that the drones had become at least partly dependent upon the workers for food, or possibly for some essential growth factor, or that they preferred regurgitated food to sucrose sirup.

Some preliminary experiments indicated that drone honey bees in cages lived longer when they had free access to levulose-sucrose sirup, than when they had access to sirups containing dextrose and levulose, dextrose and sucrose, or only sucrose. Perhaps drones cannot invert sucrose into dextrose and levulose as readily as worker bees can. Oertel *et al.* (1951) show that caged worker bees can invert sucrose sirup with considerable rapidity. Additional work is necessary to clarify the relationship in regard to food transmission between the worker and the drone honey bee. Perhaps information on the amount of care that the workers give to the adult males in the Hymenoptera would help to clarify the phylogeny of these insects.

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ERRATUM

In the December, 1952, issue of the ANNALS, page 528, the proposed new name *Ruizapis* (for *Ruiziella* Timberlake, Apoidea, *non Ruiziella* Cortés, Tachinidae) was misspelled *Ruziapis*. The name should be corrected to the intended *Ruizapis*, in accordance with Article 19 of the International Code and Opinion 27.

NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA. PART XV[1]

(Diptera: Tipulidae)

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In the present paper I am discussing a series of Tipuline crane-flies belonging to the genera *Brachypremna*, *Phacelodocera*, *Holorusia*, *Ozodicera*, and *Longurio*, all belonging to the so-called primitive Tipulinae, unusually well developed in tropical America. The types are preserved in my personal collection of these flies.

Genus **Brachypremna** Osten Sacken

Brachypremna thyestes sp. n.

Mesonotum almost uniformly polished brown, the pleura variegated with obscure yellow and brown; legs dark brown, the extreme tips of the tibiae whitened, the tarsi paling to brownish yellow; wings with a strong brownish suffusion; stigma oval, dark brown, preceded and followed by conspicuous whitened areas; cell *2nd A* very narrow; abdomen dark brown, the bases of the tergites narrowly paler, of the sternites more extensively so, hypopygium black; inner dististyle at apex expanded into a yellow blade; outer style at apex narrowed into a subacute point.

Male.—Length, about 9.5–10 mm.; wing, 12.5–13 mm.

Female.—Length, about 10 mm.; wing, 13 mm.

Frontal prolongation of head yellow, palpi black. Antennae dark brown; flagellar segments tending to become confluent, the slender terminal segment with several elongate setae. Head with the front and anterior vertex whitened, the posterior parts dark brown.

Pronotum obscure yellow. Mesonotum almost uniformly polished brown, the praescutum without distinct stripes. Pleura chiefly obscure yellow, the posterior part of the anepisternum and sternopleurite more darkened to produce a narrow transverse girdle, the anterior part of the mesopleura and the pteropleurite remaining pale. Halteres infuscated. Legs with the fore and posterior coxae weakly darkened, the middle pair yellow; trochanters yellow; remainder of legs dark brown, the extreme tibial bases vaguely whitened; tarsi paling to brownish yellow. Wings with a strong brownish suffusion; stigma oval, dark brown, conspicuous; extensive whitened prestigmal and poststigmal areas; very vague to scarcely evident darker clouds over the anterior cord and *m-cu;* veins dark brown, R_{1+2} and the tips of veins

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M_2, M_3 and M_4 pale. Venation: *Rs* relatively short, square at origin; cell *1st* M_2 longer than the distal section of vein M_3; cell *2nd A* very narrow, especially at outer end.

Abdomen dark brown, the base of the second tergite broadly, of the succeeding ones more narrowly obscure brownish yellow, the outer tergites, including the hypopygium, more uniformly blackened; outer sternites brownish yellow, the posterior borders narrowly darkened, without longitudinal lines, as common in the genus. Male hypopygium (Fig. 1) with the tergite, *9t*, transverse, narrowed outwardly, the lobes low and obtuse, glabrous, separated by a rounded notch having nearly the same outline. Outer dististyle, *d*, darkened on basal half, thence more expanded into a flattened yellow blade, the tip truncate, the lower outer angle a little produced; no spur or point on outer margin near base, as common in the genus; lower style distinctive, more than one-half the length of the upper one, narrowed at apex into a subacute point.

Habitat.—Peru. *Holotype*, ♂, Chanchamayo, Junin, altitude 1100 meters, February 12, 1949 (José M. Schunke). *Paratopotype*, ♂, altitude 1200 meters, April 18, 1949.

In its general appearance, the present fly is most like *Brachypremna arcuaria* Alexander and *B. illudens* Alexander, differing conspicuously in the pattern of the body and legs, and in the structure of the male hypopygium, especially the tergite and dististyles.

Genus **Phacelodocera** Enderlein

Phacelodocera flabellifera (Loew)

Ptilogyna flabellifera Loew, 1851, Linnaea Ent., 5: 391–393, pl. 2, figs. 1–3 (male).

The present species has always been one of the rarest of all Neotropical Tipulidae. The unique male type was collected in an unspecified part of Brazil by Beske (C. F. C. Beske, the father, collected in the vicinity of Rio de Janeiro before 1832; Carl Heinrich Beske, his son, collected in Brazil in 1834–35). The only other specimen known to me is the female described herewith as the allotype of the species.

Female.—Length, about 39 mm.; wing, 28 x 8.5 mm.; antenna, about 7 mm.

Characters as in the male, differing especially in the structure of the antennae and in details of venation. Antennae (Fig. 2) 14-segmented; scape, pedicel and the simple four terminal segments brown, the remaining segments and branches black; first flagellar segment with a single branch that is about as long as the segment; segments two to eight, inclusive, each with two long branches, the longest (about flagellar segments six or seven) approximately 3.5 times the length of the segment; branches slightly unequal, this condition more accentuated on the more proximal segments; on flagellar segment two before the tip with a fingerlike lobe that is a little more than one-fifth the segment, on the remaining branched segments excepting the last this much smaller and becoming progressively reduced in size, finally becoming very small to subobsolete; outer four segments simple, more or less knobby in appearance and showing signs of deformation; all branches

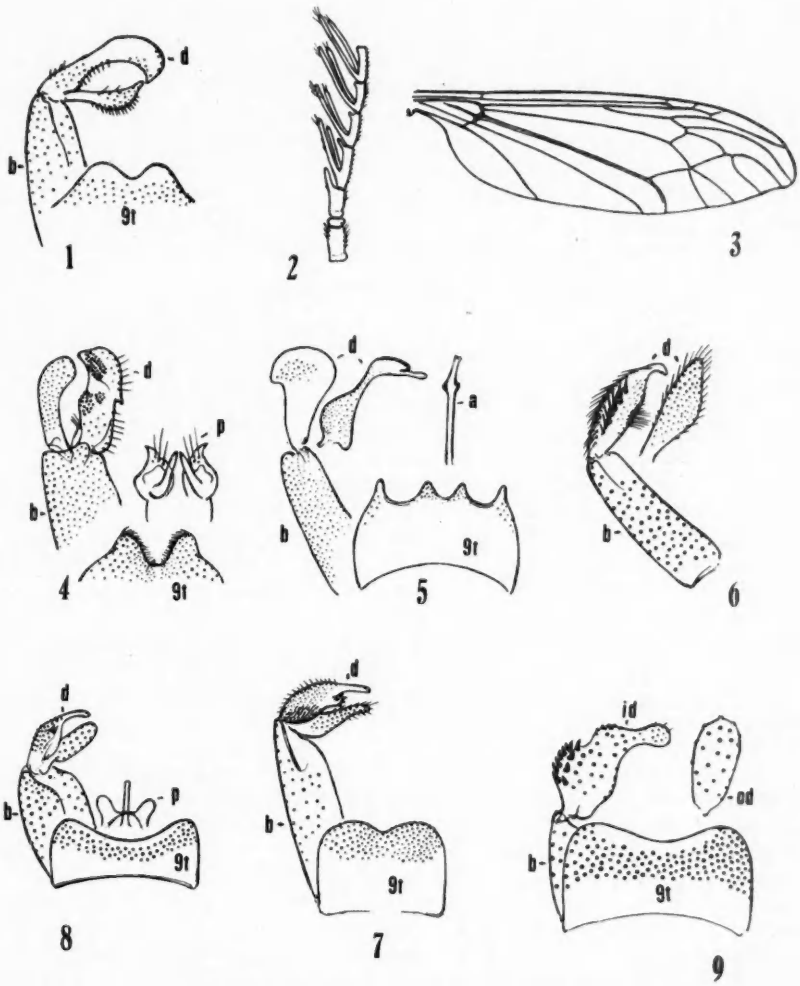

FIG. 1. *Brachypremna thyestes* sp. n.; male hypopygium. FIG. 2. *Phacelodocera flabellifera* (Loew); antenna, ♀. FIG. 3. *Phacelodocera flabellifera* (Loew); venation. FIG. 4. *Holorusia* (*Holorusia*) *tuberculifera* sp. n.; male hypopygium. FIG. 5. *Ozodicera* (*Ozodicera*) *eurystyla* sp. n.; male hypopygium. FIG. 6. *Longurio* (*Longurio*) *sessoris* sp. n., male hypopygium. FIG. 7. *Longurio* (*Longurio*) *huanucensis* sp. n.; male hypopygium. FIG. 8. *Longurio* (*Longurio*) *perglabrata* sp. n.; male hypopygium. FIG. 9. *Longurio* (*Longurio*) *rabelloi* sp. n.; male hypopygium.

Explanation of symbols: *a*, aedeagus; *b*, basistyle; *d*, dististyle; *id*, inner dististyle; *od*, outer dististyle: *p*, phallosome; *t*, tergite.

with long sparse setae. Anterior vertex behind the eyes elevated into a slender knob; anterior vertex at its narrowest point less than twice the greatest diameter of the scape; ommatidia of eyes very small and numerous. Wings (Fig. 3) broader than figured by Loew; petiole of cell M_1 even shorter, less than twice *r-m; m-cu* at fork of M_{3+4}, in alignment with the unusually long *m* which likewise joins at the fork of M_{3+4}. Ovipositor with the cerci long and very slender, straight; hypovalvae much shorter, more compressed-flattened.

Allotype, ♀, Campo Bello, Rio de Janeiro, Brazil, March 16, 1946 (José Francisco Zikan).

Genus **Holorusia** Loew

Holorusia (**Holorusia**) **celestissima** sp. n.

Size large (wing, female, 28 mm.); praescutum dark brown, the four stripes barely indicated, more reddish brown; dorsal region of thoracic pleura yellow, the central portion dark brown, the ventral pleurites yellowed; knobs of halteres light yellow; femora brown, the tips rather narrowly blackened; wings strikingly patterned with light and dark brown, yellow and whitish yellow, including a series of about nine small yellow spots in a darkened seam in cell *M* adjoining vein *Cu;* abdominal sternites obscure yellow, each with three pale brown spots.

Female.—Length, about 24 mm.; wing, 28 mm.; antenna, about 4.2 mm.

Frontal prolongation of head above obscure yellow, the ventral half infuscated, more intensely so along the sides; palpi black. Antennae with the scape yellow, pedicel more greenish, flagellum brownish black, tinged with green; segments cylindrical, decreasing in length and diameter outwardly. Head above pale, yellow pollinose, infuscated behind the eyes.

Pronotal scutellum and mesonotum dark brown medially, the four praescutal stripes vaguely indicated, more reddish brown; scutellum conspicuously yellowish gray basally on either side of a capillary median vitta; mediotergite gray pruinose, with a narrow central black line that is bordered on either side by a light gray area, the posterior border obscure yellow. Pleura with the central portion dark brown, with a broad pale yellow dorsal stripe extending from the dorsal cervical region, across the dorsopleural region to the wing base; ventral pleurites yellow, vaguely marked with brown; darkened central portion of pleura includes the ventral cervical region, anepisternum and part of the pteropleurite. Halteres with stem dusky, knob conspicuously light yellow. Legs with the coxae yellow, patterned with brown, more extensive and basal in position on the fore coxae, at near midlength on the remaining coxae; trochanters yellow; femora narrowly obscure yellow basally, passing into brown, the tips rather narrowly blackened, least conspicuously so on the hind legs; tibiae dark brown, very restrictedly brightened at base, the tip narrowly blackened, the hind tibiae paler; tarsi black; claws (female) simple. Wings strikingly patterned, brown, variegated with darker brown, light yellow and whitish yellow; costal region, especially cell *Sc*, brighter brown; the darkest areas

include the prearcular field, a postarcular darkening, an intense spot at origin of *Rs*, stigma, and narrow seams over cord and outer end of cell *1st* M_2; a broad brown seam in cell *M* adjoining vein *Cu*, this interrupted by about nine yellow spots, the outer ones larger; conspicuous yellowish white areas at arculus and as a prestigmal brightening; veins brown, more brightened in the lighter areas, including Cu_1 and *2nd A*. Venation: Cell R_3 only moderately constricted; petiole of cell M_1 and *m* subequal; *m-cu* just before the fork of M_{3+4}, about three-fifths as long as the distal section of Cu_1.

Abdominal tergites reddish brown, darker sublaterally, the extreme lateral margins yellow, narrowest on the outer segments; sternites brownish yellow, each with three pale brown spots, the central one larger.

Habitat.—Peru. *Holotype*, ♀, Chinchao, Huanuco, altitude 2500 meters, September 25, 1947 (Felix Woytkowski).

This unusually striking species of *Holorusia* needs little comparison with other large members of the genus. It appears to come closest to *Holorusia* (*Holorusia*) *luteivena* Alexander and *H.* (*H.*) *uniatra* Alexander, yet is entirely distinct in the diagnostic features listed above.

Holorusia (Holorusia) tuberculifera sp. n.

Size medium (wing, male, 18 mm.); antennae yellow; praescutum dark brown with four more reddish stripes; thoracic pleura variegated brown and yellow, the dorsopleural region broadly light yellow; femora obscure brownish yellow, the tips narrowly blackened; wings obscure yellow, patterned with brown, including a major postarcular area but with no spot at midlength of cell *M*; abdominal segments yellow basally, passing into brown; male hypopygium with the outer dististyle dilated and obtuse at apex; inner dististyle with the apex obtuse, the outer margin produced into a tubercle.

Male.—Length, about 16 mm.; wing, 18 mm.

Frontal prolongation of head yellowish brown above, blackened on ventral half; nasus unusually long and slender, subequal in length to the scape. Antennae obscure yellow, only the last segment a trifle darker; flagellar segments cylindrical. Head brown; vertical tubercle lacking; anterior vertex about three and one-half times the diameter of the scape.

Pronotum dark brown medially, paling to yellow on the sides. Mesonotum with the ground dark brown or brownish black, with four reddish stripes, the posterior interspaces more buffy gray; scutal lobes each with two reddish brown areas that are encircled with darker brown; median region of scutum obscure yellow, extended laterad at the suture; scutellum brown, darker medially and on sides at base, the central portion yellow pollinose basally; mediotergite gray pruinose, the central part with a darkened vitta, the sides more extensively darkened on the posterior half; posterior fourth of mediotergite obscure yellow, pleurotergite darkened on caudal half, paling to yellow in front. Pleura with the propleura, anepisternum, cephalic part of pteropleurite and dorsal sternopleurite dark brown, the remainder of pleura obscure yellow; dorsopleural region broadly light yellow. Halteres infuscated,

apex of knob yellow. Legs with the fore and middle coxae infuscated, the posterior coxae and all trochanters yellow; femora obscure brownish yellow, the tips narrowly brownish black; tibiae brownish black, tarsi paling to brown, the outer segments brownish black; each claw with two separated teeth. Wings with the ground color obscure yellow, the costal field clearer yellow; a relatively restricted brown pattern, as follows: postarcular area in bases of cells *R* and *M:* a somewhat smaller quadrate area at origin of *Rs:* no darkening in cell *M:* cord and outer end of cell *1st* M_2 seamed with brown; paler brown washes in outer radial field, most of cell *1st* M_2 and as vague seams to the veins; both anal cells weakly darkened, variegated with ground areas, including a major triangle in cell *1st A* near vein *2nd A:* veins brown, somewhat brighter in the paler areas. Venation: *Rs* about two and one-half times *m-cu:* vein R_3 only moderately arcuated, the cell only slightly constricted; petiole of cell M_1 slightly more than one and one-half times *m: m-cu* at fork of M_{3+4}.

Abdominal tergites with the bases obscure yellow, the color merging behind into the dark brown posterior borders; lateral margins at base conspicuously yellow; sternites less evidently bicolored, yellow basally, pale brown behind; hypopygium yellow. Male hypopygium (Fig. 4) with the ninth tergite, *9t*, bilobed, the median notch broader than either lobe; vestiture of lobes consisting of black setae, those nearer apex stouter, the basal ones long and slender. Outer dististyle, *d*, dilated and obtuse at apex; inner style a trifle longer, the apex or head obtuse, on outer margin at base of head with a small but conspicuous tubercle; blackened spicules arranged in three groups, the one on the head more extensive. Phallosome, *p*, with two triangular masses that terminate in a small acute point, each with three or four long setae.

Habitat.—Peru. *Holotype*, ♂, Tarapoto, San Martin, altitude 830 meters, March 10, 1947 (Felix Woytkowski).

Holorusia (*Holorusia*) *tuberculifera* is quite distinct from the other regional members of the genus. In its wing pattern, including the lack of a darkened area at midlength of cell *M*, it agrees with the otherwise quite distinct *H.* (*H.*) *peruviana* Alexander.

Genus **Ozodicera** Macquart

Ozodicera (**Dihexaclonus**) **biaculeata** sp. n.

General coloration of thoracic notum opaque obscure yellow, the praescutum with four more reddish stripes; branches of flagellar segments unequal, the longest a little exceeding the segments in length; wings with a strong yellowish brown suffusion, a small brown cloud over the anterior cord; male hypopygium with the tergal lobes long and narrow, subacute at tips; apex of basistyle produced into two acute spines; inner dististyle generally simple, strongly curved at midlength, with low outer flanges; phallosome consisting of a pair of strong curved darkened rods, the tips obtuse, each with a small slender apophysis.

Male.—Length, about 28 mm.; wing, 21.5 mm.; antenna, about 7.5 mm.

Frontal prolongation of head reddish brown; nasus stout; palpi black. Antennae (male) relatively long; scape and pedicel brown;

branched flagellar segments, including the branches, yellow, the simple outer segments darker; branches of flagellar segments two to seven, inclusive, relatively short, the longest a trifle exceeding the segment, the shorter one only about one-third to one-half as long, borne on the face of the longer branch, on segment two very short and more nearly apical in position, on the following segments longer and more basal in position. Head reddish brown, more or less yellow pollinose.

Mesonotum opaque, obscure yellow, the praescutum with four more reddish brown stripes; scutal lobes with reddish brown centers; scutellum and postnotum more heavily yellow pollinose. Pleura chiefly yellowish gray, the dorsopleural region more infuscated. Halteres dark brown. Legs with the coxae gray pruinose; trochanters reddish yellow; femora and tibiae reddish brown, the tips narrowly more infuscated; tarsi brownish black to black. Wings with a strong yellowish brown suffusion, the centers of cells *1st* M_2 and M_4, together with comparable areas in outer end of cell *M* and in anal cells much paler; stigma oval, pale brown, scarcely differentiated from the ground; a small but conspicuous brown cloud over the anterior cord; prearcular field likewise darker brown; veins reddish brown, darker in the more infuscated areas. Venation: Cell M_1 broadly sessile.

Abdomen elongate, reddish brown, the lateral tergal borders more darkened, hypopygium concolorous. Male hypopygium with the lobes of the tergite unusually long and slender, subacute at tips, the notch separating them wider than either lobe; surface of tergite, including the lobes but not the extreme cephalic border, with abundant setae. Basistyle at apex produced into two spines or slender blades, subequal in length, both acutely pointed, in the notch between the spines with two small denticles. Outer dististyle a broadly flattened blade, the width at near midlength about three-fourths to four-fifths the length; inner style generally simple, strongly curved at midlength and thence narrowed to the slender apex; on face of style back from tip with a long low crest, on opposite face with a slightly higher, more roughened small triangular flange. Phallosome consisting of a pair of strong curved darkened rods, at apex a little expanded, obtuse; at base of each rod with a shorter, very slender projection.

Habitat.—Peru. Holotype, ♂, Satipo, Junin, March, 1945 (P. Paprzycki).

The only approximately similar described regional species is *Ozodicera* (*Dihexaclonus*) *spilophaea* Alexander, which has the apex of the basistyle of the male hypopygium unarmed.

Ozodicera (**Ozodicera**) **eliana** sp. n.

Size small (wing, female, 13 mm.); mesonotum chiefly medium brown, the pleura yellow; flagellar serrations very small and inconspicuous, the longest on the second flagellar segment, a little shorter than the segment; wings handsomely patterned with light and dark brown and whitish subhyaline; abdominal tergites obscure yellow, conspicuously trivittate with dark brown, sternites more reddish brown.

Female.—Length, about 17 mm.; wing, 13 mm.; antenna, about 2.3 mm.

Frontal prolongation of head dark brown; nasus short and stout; mouthparts and palpi dark brown. Antennae with scape dark brown, pedicel obscure brownish yellow, flagellum brownish black, the extreme bases of the more proximal segments vaguely brightened; a single very short serration on flagellar segments two to seven, shorter on the outer two or three segments, the longest branch on second segment, a trifle shorter than the segment itself; antennae 15- or 16-segmented, there being six or seven simple outer segments; exact number of segments somewhat questionable due to the partial fusion of some of these. Head dark gray, the anterior orbits slightly clearer gray; anterior vertex about twice the diameter of the scape.

Pronotal scutum brownish black, its posterior border and the scutellum more testaceous yellow. Mesonotal praescutum with three medium brown stripes that virtually cover the disk, the anterior interspace and a comparable median dash on the cephalic third more blackened; humeral region and posterior interspaces more yellow pollinose; scutal lobes and scutellum similarly medium brown; central portion of mediotergite more pruinose, especially behind; pleurotergite and dorsal part of pteropleurite dark brown, sparsely pruinose. Remainder of pleura, including the dorsopleural region, yellow, the ventral sternopleurite more reddened. Halteres with stem pale brown, the knob whitened, the base slightly darkened. Legs with the coxae gray, a little darkened apically; trochanters yellow; femora obscure yellow basally, passing into brown, the tips conspicuously blackened; tibiae brown, the tips more narrowly blackened; tarsi passing into black. Wings handsomely patterned with light and dark brown and whitish subhyaline, the latter areas occurring as an irregular mark on basal half, beginning in cell *R* before the origin of *Rs*, crossing the outer two-thirds of cell *M;* more than the basal half of cell *Cu* whitened, interrupted by a dark outer spot; a further white subbasal area in cell *1st A;* beyond the cord a conspicuous subterminal curved white band involving the bases of the outer medial cells, reaching the border or virtually so in cells R_5 and M_4; a third white area in cell *1st* M_2 and bases of cells R_3 and R_5; stigma light yellow; the darker brown marks lie chiefly basad of the cord, appearing as broad seams to certain of the veins, the most extensive along vein *Cu* in cell *M;* veins brown. Venation: *Rs* nearly twice *m-cu;* cell M_1 broadly sessile.

Abdominal tergites obscure yellow, conspicuously trivittate with dark brown, the lateral borders broadly of this color, the continuous median stripe slightly narrower; basal rings between the stripes clearer yellow; sternites more reddish brown; terminal segments dark brown, the genital shield more polished; cerci very slender, almost straight.

Habitat.—Southeastern Brazil. *Holotype*, ♀, Boracea, São Paulo, altitude 900 meters, August 9, 1947 (Travassos Filho and Rabello).

This beautiful crane-fly is named for Miss Eliana Travassos, young daughter of Lauro and Betty Travassos, to whom I express my deep thanks for many Tipulidae from southeastern Brazil. The fly requires no comparison with any of the now numerous known species. It is most similar to *Ozodicera* (*Ozodicera*) *striatipennis* Alexander, of Venezuela, but the resemblance is not particularly close.

Ozodicera (Ozodicera) eurystyla sp. n.

Mesonotum reddish brown, the praescutum with four slightly darker brown stripes; flagellar segments each with a short stout branch that is slightly shorter than the segment; wings dark fulvous brown, the prearcular and costal fields more yellowed; male hypopygium with the caudal margin of the tergite four-lobed; outer dististyle large and flattened, widened outwardly, the apex broadly obtuse, the upper margin near apex further produced into a lobe.

Male.—Length, about 17 mm.; wing, 13.5 mm.; antenna, about 4 mm.

Female.—Length, about 21 mm.; wing, 17 mm.; antenna, about 5 mm.

Frontal prolongation of head brown; nasus short; palpi brownish black. Antennae with scape and pedicel obscure yellow, flagellum yellowish brown to brown, branches black; antennae of female longer than that of male, especially the terminal simple segments; flagellar segments two to seven, inclusive, each with a short stout branch, a little shorter than the segment, that of segment two shortest; outer segments elongate-cylindrical, simple. Head brown; anterior vertex narrow, a little more than one-half the diameter of the scape in the male, a trifle broader in the female.

Pronotum and mesonotum reddish brown, the four praescutal stripes a trifle darker brown; posterior sclerites of notum a trifle darker. Pleura and pleurotergite pale, sparsely pruinose. Halteres brown, the base of stem paler. Legs with the coxae yellow, sparsely pruinose; trochanters yellow; femora brownish yellow, the tips narrowly blackened; tibiae brown, darker at tips; tarsi black; claws (male) with a strong tooth at extreme base. Wings dark fulvous brown, the prearcular and costal fields more yellowed; stigma oval, slightly darker brown than the ground, slightly deeper in color in male. Venation: *Rs* from one-third to one-fifth longer than *m-cu*, shorter in female; cell M_1 broadly sessile.

Abdominal tergites reddish brown, conspicuously blackened laterally, the mid-dorsal area less heavily darkened; subterminal segments brownish black to form a ring; hypopygium yellow. Male hypopygium (Fig. 5) with the tergite, *9t*, transverse, its caudal margin four-lobed, the more slender lateral lobes separated from the broader intermediate pair by broad emarginations. Outer dististyle, *d*, large and flattened, widened outwardly, the apex broadly obtuse; upper margin near apex farther produced into a lobe; inner style broad-basally, the swollen portion with abundant long pale setae; stem slender, the dilated head unequally bilobed, the whole more or less suggestive of the head and neck of a duck. Aedeagus, *a*, long and slender, with a pair of swellings before tip.

Habitat.—Peru. *Holotype*, ♂, Cachiyacu, Upper Ucayali River, Loreto, April 21, 1947 (José M. Schunke). *Allotopotype*, ♀, pinned with type.

Entirely different from all other described regional species, including *Ozodicera* (*Ozodicera*) *bispinifer* Alexander and *O.* (*O.*) *thaumasta* sp. n., particularly in the structure of the male hypopygium.

Ozodicera (Ozodicera) thaumasta sp. n.

Size relatively large (wing, male, 19 mm.); general coloration of mesonotum opaque buffy yellow, the praescutum with four very slightly darker reddish brown stripes; wings with a strong brownish gray suffusion, the costal border and stigma somewhat darker brown; male hypopygium with the caudal margin of the tergite virtually truncate; basistyle not armed at apex; inner dististyle with three conspicuous blackened rods; phallosome more or less resembling a pitchfork, the two spines very slender and acute.

Male.—Length, about 24 mm.; wing, 19 mm.; antenna, about 6.6 mm.

Frontal prolongation of head relatively long, subequal to remainder of head, reddish brown, more or less patterned with dark brown; nasus stout; palpi black. Antennae relatively long; scape brownish yellow, pedicel clearer yellow, basal flagellar segments obscure yellow, the outer ones passing into black; flagellar branches black, the longest nearly equal in length to the segments; branches virtually simple, without accessory lobes or tubercles but with a microscopic seta before apex. Head above dark; anterior vertex relatively narrow, about equal to the diameter of the scape.

Pronotum and mesonotum chiefly opaque buffy yellow or reddish yellow, the praescutum with four very slightly darker reddish brown stripes, the lateral pair vaguely margined by slightly darker brown; posterior sclerites of notum a little darker, yellow or grayish yellow pollinose. Pleura and pleurotergite yellow, more or less pruinose. Halteres blackened, relatively slender. Legs with the coxae yellowish gray; trochanters pale brown; remainder of legs brown, the tarsi passing into black. Wings with a strong brownish gray suffusion, the prearcular and costal fields, with the stigma, somewhat darker brown; veins brown. Venation: Cell M_1 broadly sessile.

Abdominal tergites reddish brown, the sternites more yellowed; segments seven and eight more uniformly brownish black; hypopygium yellow. Male hypopygium with the caudal margin of the tergite virtually truncate, without an emargination, the border with a very small lobule on either side of a broad central space. Basistyle unarmed. Outer dististyle a long flattened pale blade; inner style with three conspicuous blackened rods. Phallosome a central blackened structure that forks into two slender spines, their tips very acute, the whole structure more or less resembling a pitchfork.

Habitat.—Peru. *Holotype*, ♂, Satipo, Junin, April, 1945 (P. Paprzycki).

Ozodicera (*Ozodicera*) *thaumasta* is most similar to species such as *O.* (*O.*) *bispinifer* Alexander and *O.* (*O.*) *phallacantha* Alexander, yet entirely distinct in all details of structure of the male hypopygium, particularly the tergite, inner dististyle and phallosome.

Genus **Longurio** Loew

Longurio (Tanypremna) aurantiothorax sp. n.

Head and thorax uniformly orange; antennae with scape and pedicel yellow, flagellum black; femora broadly yellow basally, the

tips blackened; wings with the basal third or more conspicuously yellow, cells *C* and *Sc* more brownish yellow; stigma oval, brownish black, very conspicuous; veins beyond cord brownish black, the basal and costal ones yellow; Sc_1 virtually atrophied; *Rs* short, strongly arcuated; *r-m* much reduced, cell *1st* M_2 correspondingly widened, approximately as broad as long; *m-cu* at or just before midlength of M_{3+4}.

Female.—Length, about 14 mm.; wing, 10.5 mm.

Frontal prolongation of head orange, short, without a nasus but with numerous black setae; palpi brown, the terminal segment black. Antennae 13-segmented; scape and pedicel yellow, flagellum black; basal flagellar segments short, suboval, the first constricted basally; outer segments passing into cylindrical, with numerous very long verticils. Head uniformly orange; anterior vertex broad, approximately five times the diameter of scape; vertical tubercle very low.

Thorax uniformly orange, shiny. Halteres yellow. Legs with the coxae and trochanters yellow; femora broadly yellow basally, more darkened outwardly, the tips blackened; tibiae brown basally, the remainder blackened; tarsi black. Wings with the basal third or more conspicuously yellow, cells *C* and *Sc* more brownish yellow; stigma oval, brownish black, very conspicuous; wing tip insensibly more darkened than the subterminal portions; veins beyond cord brownish black, the basal and costal ones, as well as *Cu*, yellowed. Veins beyond cord glabrous. Venation: Sc_1 faintly indicated to virtually atrophied, widely separated from the free tip of Sc_2; *Rs* short, strongly arcuated; R_{2+3} longer than *Rs*; *r-m* much reduced, cell *1st* M_2 correspondingly large, approximately as broad as long; basal section of M_{1+2} gently arcuated, longer than the second section; petiole of cell M_1 subequal to or slightly shorter than *m*; *m-cu* from two-fifths to midlength of M_{3+4}; cell *2nd A* broad.

Abdomen orange, with a subterminal black ring involving segments eight and nine, together with much of tergite seven; genital shield blackened on basal half, the basal part chestnut; cerci blackened, hypovalvae more chestnut yellow.

Habitat.—Peru. *Holotype*, ♀, Cerro Azul, Contamana, Loreto, April 20, 1947 (José M. Schunke).

In its venation, particularly the broad cell *1st* M_2, the present fly is related to *Longurio* (*Tanypremna*) *bezziana* (Alexander), likewise from Amazonian Peru. This latter fly differs conspicuously in the coloration of the body and wings and in the details of venation. Unfortunately both of these somewhat isolated flies are still known only from females.

It has become increasingly apparent that several supposedly valid generic groups in the so-called primitive Tipulinae are actually very closely allied and certain of these may fall in the synonymy while others may be maintained as subgenera. I am considering *Tanypremna* Osten Sacken, with various closely allied groups, and *Macromastix* Osten Sacken, to be subgenera of the older *Longurio* Loew and am so treating them at this time. The subgenera that center about *Tanypremna* have been discussed by the writer in earlier reports (Ann. Mag. Nat. Hist., ser. 10, 20: 483–485, 1937, and ser. 11, 1: 337–339, 1938).

Longurio (Tanypremna) phylax sp. n.

Size small (wing, female, 11 mm.); mesonotum polished obscure yellow, the praescutum with four brownish black areas, the intermediate pair incomplete; head orange, the vertical tubercle very high and conspicuous; antennae apparently only 11-segmented; femora, tibiae and basitarsi yellow, their tips brownish black; wings relatively short and broad; prearcular and costal fields strongly yellowed, the apical and posterior margins weakly but broadly infuscated, leaving more yellowed discal areas on either side of the cord; stigma darker brown; *Rs* and R_{1+2} unusually long, *m-cu* at fork of M_{3+4}; ovipositor with cerci appearing as broad compressed-flattened blades; hypovalvae very reduced, terminating in needle-like points.

Female.—Length, about 12 mm.; wing, 11 mm.

Frontal prolongation of head relatively short, obscure yellow; nasus long and conspicuous; palpi relatively short, black. Antennae apparently either 10- or 11-segmented; scape and pedicel yellowish brown, flagellum dark brown; first flagellar segment strongly protuberant on lower face, succeeding segments subcylindrical, the outer ones tending to become fused; verticils (female) relatively short. Head orange; vertical tubercle very high and conspicuous, appearing as an obtuse knob.

Pronotum very narrow; scutum obscure yellow medially, blackened on sides; scutellum even more reduced, only the blackened lateral parts evident. Mesonotum polished obscure yellow, the praescutum with four brownish black areas, two on the anterior end of the sclerite representing the cephalic ends of the usual intermediate stripes, the other pair larger, representing the lateral stripes, these continued backward across the suture onto the extreme anterior margin of the scutal lobe. Pleura obscure yellow, propleura black, reduced in size; mesonotum darker and more pruinose, the posterior sclerites more shiny; dorsopleural membrane extensive, yellow. Halteres with stem yellow, knob infuscated. Legs with the coxae light brown, pruinose, the anterior pair somewhat darker; trochanters yellow; femora, tibiae and basitarsi yellow, their tips rather narrowly but conspicuously dark brown or brownish black; remainder of tarsi black. Wings rather short and broad; prearcular and costal fields, together with cell *2nd A*, strongly yellowed, the remaining margin weakly but broadly infuscated, leaving more cream-yellow discal areas on either side of the cord; stigma and narrow seams over the cord darker brown; veins beyond cord, as well as *M* and *1st A* brownish black, the remaining basal veins more yellowed. Weak but relatively numerous macrotrichia on outer section of vein R_{4+5}, lacking or virtually so on veins beyond cord. Venation: Sc_1 weakly preserved, at tip of Sc_2; *Rs* unusually long; free tip of Sc_2 and R_1 subequal; R_{1+2} elongate, exceeding one-half the length of R_{2+3}; petiole of cell M_1 about one-half to one-third longer than *m*; *m-cu* at fork of M_{3+4}, the latter short; cell *2nd A* broad.

Abdominal segments obscure brownish yellow, the lateral borders more blackened, the posterior margins more narrowly so; genital shield testaceous yellow. Ovipositor with the cerci conspicuous, appearing as compressed-flattened blades, their lower edges setulose; hypovalvae very reduced, each terminating in a needlelike point.

Habitat.—Peru. *Holotype*, ♀, Fundo Sinchono, Cordillera Azul, Huanuco, altitude 1500 meters, August 29, 1947 (José M. Schunke).

A very distinct fly, apparently most nearly allied to species such as *Longurio* (*Tanypremna*) *carbonipes* (Alexander), differing in the coloration of the body and wings and in the structure of the antennae, head and ovipositor. The last is very peculiar, somewhat suggesting the condition in the subgenus *Vestiplex* Bezzi, of the genus *Tipula* Linnaeus.

Longurio (Tanypremna) uniguttata sp. n.

Size large (wing, female, over 20 mm.); praescutal stripes dull yellow; large black spots at cephalic and lateral portions of the praescutum; thoracic pleura yellow, with an incomplete transverse brownish black girdle; femora obscure yellow, the tips broadly blackened; wings with a brownish tinge, the stigma and a major cloud over the anterior cord dark brown; vein R_3 with a series of macrotrichia; *Rs* short and oblique; R_{2+3} strongly arcuated at origin; abdomen elongate.

Female.—Length, about 32 mm.; wing, 21.5 mm.; abdomen alone, about 27 mm.

Frontal prolongation of head short, orange, restrictedly more infuscated on sides; palpi black. Antennae 13-segmented; scape obscure yellow, pedicel more brownish yellow, flagellum dark brown, the base of the first segment narrowly yellow; flagellar segments chiefly cylindrical, the more proximal ones stouter, the outer segments weakly constricted; verticils of the outer three or four segments conspicuous. Head above orange, more intense behind; vertical tubercle of moderate height.

Pronotum darkened medially and on sides, leaving very restricted paler sublateral areas, the lateral portions intensely blackened. Mesonotal praescutum with the humeral areas golden yellow, the usual stripes duller yellow; cephalic border broadly and conspicuously blackened; a circular brownish black lateral spot behind the pseudosutural foveae; posterior interspaces similarly darkened; scutal lobes chiefly obscure testaceous yellow, the lateral and central portions weakly more infuscated; posterior sclerites of notum brownish yellow; central area of scutum with a group of small black setulae. Pleura and pleurotergite yellow, with a conspicuous brownish black transverse stripe, extending from the lateral praescutal area across the dorsopleural membrane, covering the anepisternum and dorsal part of the sternopleurite. Halteres with stem yellow, knob infuscated. Legs with the coxae and trochanters yellow; femora obscure yellow, the tips broadly and conspicuously blackened; tibiae brownish yellow, the tips more narrowly blackened; basitarsus obscure yellow, the tip and remainder of tarsus black. Wings with a strong brownish tinge, the prearcular and costal fields even more darkened; stigma relatively small, dark brown; a single conspicuous dark brown cloud over the anterior cord; veins dark brown, those in the basal and costal fields somewhat paler. A series of macrotrichia on vein R_3, lacking on remaining veins beyond cord. Venation: Sc_1 weakly preserved, widely separated from the free tip of Sc_2, the latter and R_{1+2} pale; *Rs* short and oblique; R_{2+3} strongly arcuated at origin; R_2 short; petiole of cell

M_1 shorter than *m; m-cu* a short distance before the fork of M_{3+4}; cell *2nd A* broad.

Abdomen elongate, as shown by the measurements; basal tergites light yellowish brown, the outer segments more darkened; basal sternites yellow, the outer ones more darkened medially; ovipositor with the cerci long and straight, black, the tips abruptly orange; hypovalvae long, compressed-flattened, the tips subacute.

Habitat.—Peru. *Holotype*, ♀, Divisoria, Cordillera Azul, Huanuco, altitude 1600 meters, September 4, 1947 (José M. Schunke).

The present fly is allied to species such as *Longurio* (*Tanypremna*) *horrida* (Alexander), *L.* (*T.*) *kadeni* (Alexander), and others, differing very evidently in the coloration of the body, legs and wings.

Longurio (Longurio) sessoris sp. n.

Size medium (wing, male, under 14 mm.); general coloration of mesonotum of male orange, more infuscated in female; frontal prolongation of head elongate, orange-yellow; antennae short, scape and pedicel yellow, flagellum brownish black; wings with a weak brownish tinge; petiole of cell M_1 subequal to *m;* abdominal segments brownish yellow, variegated with brown; male hypopygium with the basistyle elongate; inner dististyle terminating in a yellow compressed blade or beak, the surface of the style with a double row of from ten to twelve strong black spinous setae; longest bristles of the style retrorse.

Male.—Length, about 10 mm.; wing, 13.5–13.7 mm.; antenna, about 1.2 mm.

Female.—Length, about 11 mm.; wing, 11.5 mm.

Frontal prolongation of head long and slender, subequal to remainder of head, orange-yellow, without nasus; palpi black. Antennae short in both sexes, 12-segmented; scape and pedicel yellow, flagellum brownish black. Head orange; anterior vertex broad.

Pronotum brown. Mesonotal praescutum and scutum of male orange, unpatterned or virtually so; posterior sclerites of notum weakly infuscated. Pleura and pleurotergite yellow. In the female, the mesonotum is almost uniformly brown, the anterior sclerites much darker then in the male. Halteres elongate, dark brown, the extreme base of stem yellow. Legs long and slender; coxae and trochanters pale yellow; femora obscure brownish yellow, the tips narrowly brownish black to black; tibiae and tarsi brownish black; claws of both sexes small and simple. Wings with a weak brownish tinge, the costal region and outer radial field a little darker; stigma oval, medium brown; veins brown. Veins beyond cord glabrous or virtually so, even R_{4+5} with only sparse scattered trichia. Venation: *Rs* about one-half longer than R_{2+3}, the latter very slightly longer than *m-cu;* vein R_{1+2} entire but weak; petiole of cell M_1 subequal to *m;* cell *1st* M_2 relatively large, pentagonal; *m-cu* close to fork of M_{3+4}; cell *2nd A* moderately broad, especially near outer end.

Abdomen obscure brownish yellow, the posterior and lateral borders of the segments brown, the amount greater in the male; subterminal segments blackened to form a narrow ring; hypopygium reddish brown; sternites more uniformly yellow. Ovipositor with the valves elongate, cerci slender, straight. Male hypopygium (Fig. 6) with the caudal

margin of the tergite nearly truncate to very feebly emarginate. Basistyle, *b*, elongate, simple. Dististyle, *d*, terminal, superimposed (shown separately to avoid confusion); outer style slightly longer than the inner, its apex obtuse; outer setae long and conspicuous, black; inner style terminating in a yellow compressed blade or beak; surface of style with a ridge bearing a double row of ten or twelve strong black spinous setae that are directed outwardly, the more basal ones weaker; longest bristles of the style retrorse.

Habitat.—Peru. *Holotype*, ♂, Chanchamayo, Junin, altitude 1200 meters, February 18, 1949 (José M. Schunke). *Allotopotype*, ♀, pinned with type. *Paratopotype*, ♂, February 12, 1949.

This species is quite distinct from other regional members of the genus in the coloration and structure of the male hypopygium. The most similar of such species is *Longurio* (*Longurio*) *huanucensis* sp. n., which differs in coloration, antennal structure and in all details of structure of the male hypopygium.

Longurio (Longurio) huanucensis sp. n.

Size small (wing, male, less than 11 mm.); mesonotum vaguely infuscated, pleura yellow, the ventral pleurites more infuscated; antennae (male) approximately two-thirds the length of the wing, basal segments yellow, the outer ones dark brown; flagellar segments without verticils but with a short dense pale pubescence; wings brownish yellow; *Rs* short, R_{1+2} preserved; abdominal segments yellow, ringed posteriorly with dark brown; male hypopygium with the outer dististyle produced at end into a slender pale beak, the lower beak reduced to a knob that is set with about five blackened spinous setae.

Male.—Length, about 8–9 mm.; wing, 9–10.5 mm.; antenna, about 6.5–7 mm.

Frontal prolongation of head relatively short, brown to dark brown, without nasus; palpi black. Antennae (male) 13-segmented, elongate, as shown by the measurements, being approximately two-thirds the length of the wing; scape and pedicel very short, testaceous yellow, basal flagellar segments brownish yellow, the outer ones passing into dark brown; flagellar segments elongate-cylindrical, with abundant short erect pale pubescence but without verticils; first flagellar segment very short, subequal in length to the scape and scarcely one-fifth as long as the second; succeeding segments gradually decreasing in length, terminal segment very small. Head opaque pale brown, heavily yellow pollinose, especially in front; vertical tubercle relatively high, narrow, extending between the antennal bases.

Pronotum reduced, dark brown. Mesonotal praescutum chiefly chestnut yellow medially, the lateral portions a little darker, enclosing a vague obscure yellow sublateral stripe; scutum and scutellum vaguely infuscated; mediotergite brownish yellow, pleurotergite clearer yellow. Pleura yellow, sternopleurite conspicuously infuscated, involving to a lesser degree the ventral anepisternum and the mid-coxae. Thorax unusually glabrous, the most conspicuous setae on the scutellum. Halteres elongate, stem pale, knob infuscated. Legs with coxae yellow, the middle pair somewhat darker, as above described; trochanters yellow; femora yellow basally, passing into brown; tibiae

brownish yellow, the tips narrowly darkened, tarsi passing into black; tibial spurs conspicuous; claws simple. Wings brownish yellow, the prearcular and costal fields, with the stigma, slightly darker brown; veins delicate, pale brown. Veins beyond cord unusually glabrous, with relatively numerous trichia on outer section of R_{4+5} and on M_1. Venation: Sc_1 usually preserved, in cases atrophied, ending about opposite one-third to two-thirds *Rs*, Sc_2 a short distance from its tip; *Rs* short and pale, subequal to or only a little longer than the basal section of R_{4+5}, in cases shorter than this latter element; R_{1+2} preserved; petiole of cell M_1 from one and one-half to twice *m*; *m-cu* on M_4 shortly beyond the vertical origin; cell *2nd A* moderately broad.

Abdominal segments obscure brownish yellow, the basal segments clearer yellow; posterior borders of the segments conspicuously ringed with dark brown, the eighth sternite uniformly darkened; hypopygium chiefly obscure yellow; in cases the tergites more uniformly darkened, especially at the midline. Male hypopygium (Fig. 7) with the tergite large, nearly parallel-sided, its caudal border shallowly emarginate; very abundant setae on about the outer third. Basistyle, *b*, elongate, with relatively few setae, all delicate. Inner dististyle, *d*, produced at end into a slender pale rod or beak, the lower beak represented by a knob that bears five or six short blackened spines; outer surface of body of style with relatively numerous erect to retrorse slender setae; outer style about equal in length, narrowed gradually to the narrowly obtuse tip, provided with abundant setae.

Habitat.—Peru. *Holotype*, ♂, Pillao, Huanuco, altitude 2700 meters, in fog forests, March 9, 1946 (Felix Woytkowski). *Paratopotypes*, 5 ♂♂, February 23–March 9, 1946.

The most similar regional species is *Longurio* (*Longurio*) *pygmaea* (Alexander), which while generally similar in size and color, differs in the details of coloration and structure and in the venation, as the atrophied R_{1+2}.

Longurio (Longurio) perglabrata sp. n.

Size small (wing, male, about 9 mm. or less); praescutum light brown, with four poorly indicated more yellowed stripes; rostrum very short; antennae 11-segmented, very small; halteres elongate; wings uniformly brownish gray, unpatterned; veins pale and weak, virtually without macrotrichia; male hypopygium with the caudal border of tergite broadly emarginate; rostral prolongation of the inner dististyle long and slender, on face of style with a lobule that bears two spinous setae.

Male.—Length, about 6.5–7 mm.; wing, 8.3–9.2 mm.; antenna, about 0.5–0.6 mm.

Frontal prolongation of head much reduced, grayish brown; palpi similarly reduced, brown. Antennae 11-segmented, very small; scape, pedicel and basal three or four flagellar segments yellow, the outer ones brownish black and provided with long conspicuous verticils; first flagellar segment long, subequal to the succeeding two segments combined. Head dark brown; vertex broad, approximately three times the greatest diameter of the scape; vertical tubercle large, simple.

Pronotum dark brown, very thin and collarlike, jutting dorsad

above the level of the head. Mesonotum light brown, the praescutum with four very vaguely indicated obscure yellow stripes, the scutal lobes similarly colored; lateral borders of mediotergite narrowly dark brown. Pleura obscure brownish yellow, still paler ventrally. Halteres elongate, stem pale, knob infuscated. Legs with the coxae and trochanters yellow; remainder of legs long and slender, brown; claws simple. Wings uniformly brownish gray, unpatterned; veins pale, relatively inconspicuous against the ground. Veins very weak and tending to become evanescent, without macrotrichia excepting on the costal vein and a series on vein *R* beyond origin of *Rs*, best-indicated in the vicinity of the stigma. Venation: *Sc* relatively short, Sc_2 entering *R* about opposite two-thirds the length of *Rs;* free tip of Sc_2 jutting distad of the level of R_2, exceeding the latter in length; vein R_3 not exceeding twice the length of R_{2+3}; cell *1st* M_2 apparently normally closed but with the basal section of M_3 weak and evanescent in some specimens; cell M_1 variable in length, in cases very deep; cell *2nd A* about twice as broad as in *insidiosa*. In *insidiosa*, *Sc* is longer, *Rs* straighter; vein R_3 very long, nearly three times R_{2+3}; cell M_1 subequal in length to its petiole; cell M_4 widened at base, *m-cu* correspondingly long; cell *2nd A* narrow.

Abdomen, including hypopygium, brown, the lateral and caudal borders of the sternites somewhat paler. Male hypopygium (Fig. 8) with the tergite, *9t*, transverse, the caudal border broadly emarginate; outer half of dorsal surface with abundant strong setae, the actual margin without these. Inner dististyle, *d*, with its rostral prolongation long and relatively slender; on face of body of style with a lobule that is tipped with two blackened spinous setae; vestiture of style coarse and erect.

Habitat.—Southeastern Brazil. *Holotype*, ♂, Boracea, São Paulo, altitude 900 meters, September 15, 1947 (Travassos Filho and Rabello). *Paratopotypes*, 2 ♂♂. Type returned to Travassos.

The closest described ally of the present fly is *Longurio* (*Longurio*) *insidiosa* (Alexander), which differs in the larger size, produced frontal prolongation and mouthparts, different coloration, including the red head, and in other characters.

Longurio (Longurio) rabelloi sp. n.

Mesonotum medium brown, the praescutum without distinct stripes; antennae 11-segmented, short; frontal prolongation of head relatively long; wings with a strong brownish tinge, cells *C* and *Sc*, with the stigma, darker brown; macrotrichia of veins beyond cord relatively abundant; vein R_{1+2} weak, its tip atrophied; petiole of cell M_1 about twice *m*, cell M_4 widest at base; abdominal tergites brown, the posterior third or more of each deepening to black, hypopygium yellowish brown; male hypopygium with the posterior border of tergite broadly emarginate; rostrum of the inner dististyle relatively stout, constricted before the rounded apex, the base of style with about a dozen strong spinous setae.

Male.—Length, about 8 mm.; wing, 10 mm.; antenna, about 1.2 mm.

Frontal prolongation of head relatively long, a little shorter than

the transverse diameter of the eye, reddish brown, darkened at tip, nasus lacking; palpi brownish black. Antennae 11-segmented, short; scape obscure yellow, pedicel clearer yellow, flagellum black; flagellar segments constricted basally, dilated at outer ends; third and succeeding flageller segments with long conspicuous verticils, especially on the outer segments. Head deep reddish brown or fulvous; vertical tubercle high, simple.

Pronotum very reduced, pale brownish yellow. Mesonotum medium brown, the praescutum without distinct stripes; postnotum more yellowish brown. Pleura brownish yellow, unpatterned. Halteres brownish black, yellow basally, of moderate length. Legs with the coxae and trochanters yellow; femora brownish yellow, the tips very narrowly black; tibiae and tarsi black; claws simple. Wings with a strong brownish tinge, cells *C* and *Sc*, with the stigma, a little darker brown; veins dark brown. Macrotrichia of veins relatively abundant, beyond the cord with continuous series on veins R_{2+3}, R_3, R_{4+5} and M_1; remaining veins glabrous or virtually so. Venation: Sc_1 weakly preserved, Sc_2 ending about opposite three-fourths *Rs;* R_{1+2} weak, its tip atrophied; petiole of cell M_1 about twice *m; m-cu* gently sinuous, at near midlength of vein M_{3+4}; cell M_4 widest at base; cell *2nd A* of moderate width.

Abdominal tergites brown, the posterior third or more deepening to black; sternites yellow; subterminal segment more uniformly blackened; hypopygium yellowish brown. Male hypopygium (Fig. 9) with the tergite, *9t*, large, its posterior border broadly emarginate; outer half with numerous coarse black setae, the actual posterior border with delicate setulae. Outer dististyle, *od*, shown detached, long-oval in outline, with coarse setae, the outer ones largest; inner style, *id*, with the rostrum relatively stout, constricted before the rounded apex; base of style with about a dozen strong spinous setae.

Habitat.—Southeastern Brazil. *Holotype*, ♂, Boracea, São Paulo, altitude 900 meters, November, 1947 (Travassos Filho and Rabello). Type returned to Travassos.

The species is dedicated to Mr. E. Rabello, who collected various Tipulidae at Boracea while accompanying Lauro Travassos Filho. The most similar species is *Longurio* (*Longurio*) *tijucana* (Alexander), which differs in the body coloration, venation and trichiation of the wings, and in all details of structure of the male hypopygium.

Longurio (Longurio) zikanella sp. n.

Belongs to the *lemniscata* group, closest to *exempta:* thorax almost uniformly polished black, with very faint bluish reflections; legs black, only the bases of the fore femora restrictedly obscure yellow; wings with about the cephalic half dark brown, the posterior portion, involving cells *Cu*, the Anals, and outer medial field more brownish gray; two conspicuous bright yellow discal areas, the larger shortly before outer end of cell *M;* cell *2nd A* unusually narrow.

Female.—Length, about 13 mm.; wing, 10.5 mm.; antenna, about 2.2 mm.

Frontal prolongation of head brownish black; palpi black. Antennae black throughout, 10-segmented; flagellar segments cylindrical, becom-

ing progressively more slender outwardly, the terminal segment unusually slender; verticils shorter than the segments. Head with the anterior vertex produced cephalad beyond the level of the base of the frontal prolongation, obscure orange, darker behind; vertical tubercle virtually entire.

Thorax almost uniformly polished black, the dorsum with very faint more bluish reflections, unusually glabrous. Dorsopleural region dusky. Halteres blackened. Legs black, only the bases of the fore femora restrictedly obscure yellow, involving approximately the basal fourth. Wings with about the cephalic half dark brown, the posterior portion, involving cells *Cu*, anals and outer medial field, paler, brownish gray; two conspicuous bright yellow discal areas, the larger in cell *M* shortly before outer end, the other in the outer radial field in cells R_3 and R_5, shortly before midlength of the cells, more extensive in R_5; veins brown, a trifle more brightened in the yellow areas. Venation: Cell M_1 from one-third to one-half longer than its petiole; cell *2nd A* unusually narrow.

Abdomen, including the basal shield and valves of ovipositor, black.

Habitat.—Southeastern Brazil. *Holotype*, ♀, Barracao, Rio de Janeiro, November 17, 1943 (J. F. Zikan); "a pair were found *in copula* but the male escaped."—Zikan.

This striking fly is named for the late José Francisco Zikan (1881–1949), to whom we are indebted for much of our knowledge of the rich insect fauna of the Parque Nacional do Itatiaia. The species is most similar to *Longurio* (*Longurio*) *exempta* (Alexander), differing evidently in the coloration of the body, antennae, legs and wings.

BOOK NOTICES

THE METHODS AND PRINCIPLES OF SYSTEMATIC ZOOLOGY, by Ernst Mayr, E. Gorton Linsley, and Robert L. Usinger. Pp. ix+328, 45 figs. McGraw-Hill Co., New York. 1953. Price $6.00.

The publication of this book is a mile-post in the history of systematic zoology. Its contents have, in large part, become familiar to the more competent and careful systematist, but only after much experience, wide reading, a certain amount of trial-and-error, and frequently mistakes which he has subsequently regretted. It is encouraging to see a pioneer work and first edition that brings under one cover so much practical information and treats it in so concise and readable fashion. The experienced taxonomist will find it a useful reference, although in almost all cases, at least, he can read it as well for new ideas; to the beginner, it will be an aid to a short-cut to the mastery of the methodology and, to an extent, the philosophy, of systematics, which his predecessors have had to obtain in a much more laborious way.

The book is divided into three parts. The first, after an historical introduction and an exposition of the tasks of the taxonomist, attempts to give the authors' concept of the species, of grouping of populations within a species (infraspecific categories), and of groupings of species (higher categories). We find here discussions of such things as sibling species ("those . . . near the invisible end of the spectrum of morphological species differences," p. 81); of allopatric and sympatric forms, polytypic and monotypic species, clines, superspecies, and treatment of hybrids and parthenogenetic forms. The reader who expects to find a detailed discussion of speciation will be disappointed, but he can readily turn to other sources for such material.

The second part deals with taxonomic procedure: making and caring for collections, identification, the discrimination and utilization of taxonomic characters, the construction of descriptions and keys, illustration, and the preparation of papers for publication. An important chapter deals with quantitative methods of analysis as applied to systematics. Another section of particular significance, dealing with taxonomic discrimination, attempts to present standards whereby one may determine whether a given form is a species, subspecies, or a variant, whether intrinsic, polymorphic, ecological, or otherwise. This is the most concise and objective treatment of this question that has come to my attention, though certain of the premises of the argument will be questioned by many systematists, including the reviewer.

The third part deals with questions of zoological nomenclature. The basic foundation of this section is the International Code, which is frequently quoted or cited but not reproduced *in toto*. Nomenclatorial matters are handled in a systematic way which makes reference relatively easy, as well as lending to better readability; it therefore becomes unnecessary to skip from original sections to various opinions and special rulings, as one often has to do when he uses the Code, in order to determine an issue. The Code, of course, still remains an original source, with all the importance and implications of such, so far as the professional taxonomist is concerned. Much material that is not found in the Code, some of it controversial, is added, and the recommendations concerning taxonomic ethics are expanded into a chapter which every systematist should read. Unfortunately, human frailties extend to scientific workers, and the taxonomist is, indeed, a neophyte, who has not at one time or another witnessed violations of some of the principles of taxonomic ethics or been guilty of some of them himself.

The authors have left some questions unanswered and others insufficiently treated. Since editorial requirements and preferences vary, consideration might have been given, in respect to preparation for publication, to selection of the publication medium. Insufficient discussion is given to such topics as how much distributional information should be given in taxonomic papers. The bad practice of many taxonomists (fortunately, an increasingly less common one) of giving proportional measurements made by the eye rather than by instruments, and usually without a statement that such is the case, might have been emphasized. The index, always a difficult part to prepare, might have been improved so as to make it more usable, but some of its deficiencies are removed by the glossary, a unique feature in a work of this kind.

The overall impression given by this book is that it is an excellent treatment of a hitherto untreated subject. The biases of the authors are apparent, as well as the fact that examples are taken chiefly from the fields in which the authors have specialized. In the case in hand, however, this is not objectionable from the standpoint of the entomologist, and improvement in this respect should be expected in future revisions.—M. T. J.

THE ANTS OF CALIFORNIA, by THOMAS WRENTMORE COOK. xvi+462 pages, illus. Pacific Books, Palo Alto, Calif. 1953. Price $10.00.

When the editor invited me to review this book, I accepted with alacrity. If any state merits a *book* about its ant fauna, it is certainly California, with its unusual diversity of climate, topography and biota. I envisioned a work with good keys (perhaps illustrated with simple sketches of key characters) to the ants of the state; brief and simple descriptions; extensive accounts of the habits, distribution, behavior and ecology—in short, the natural history—of each kind of ant, illustrated with photographs of habitats and nests, and finally, a general account of the distribution and ecology of the ants of the state.

The book I received was handsomely bound, attractively illustrated and printed on excellent paper. I began work eagerly, but disillusionment set in with the introduction and was complete when I finally realized that this treatise is grossly padded, deals only cursorily with the ants of California and abounds in errors too numerous and far too serious to be excused on the ground of ordinary human frailty. There are biological, entomological, myrmecological and typographical errors; errors in spelling and grammar; errors in nomenclature and

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taxonomy; in labelling and in drawing; in quotation and translation; in make-up, lay out and typographical style. And besides that, the author's literary style is awkward, amorphous and slovenly.

Approximately three-fourths of the text is taken up with quotations. These are mostly the original descriptions of genera, species, etc., and, where the original is ancient or brief, with "revised descriptions" by recent myrmecologists. Even if accurately quoted—and a spot-check shows that some are not—what purpose do they serve? Ant specialists already have the material or know where to get it. This book is dedicated to the naturalists of California, who are certainly not interested in the vagaries of nomenclature nor the minutiae of taxonomy.

Our author does not hold with keys. "Identification factors in any taxonomy are based largely on the workers. For this reason, illustrations, descriptions, habits, and locality are used in this book as identification factors instead of the ordinary dichotomous keys originated by Mayr in the middle of the past century for identifying most forms of animals and plants." What he calls a key is a collection of 34 drawings of ants in side view (legs omitted), one for each California genus, arranged in the customary generic sequence, except for two out of place at the end. This is the only original key in the book. There are four quoted keys: three from Smith's 1947 synopsis (U. S. genera of Dolichoderinae, U. S. genera of Formicinae and the groups of the subgenus Formica) and one from Creighton (1930) to four forms of *Solenopsis xyloni*.

The illustrations are not numbered but I have counted 366 drawings, about a third of which are original, as evidenced by the signature of the artist, Marian A. Kendall. As for the others there are no credits with the drawings nor in the acknowledgments, unless one counts the understatement that the styles of Smith's and Creighton's artists have been followed. Forty-nine of these uncredited drawings practically duplicate (except for a slight reduction) drawings of Creighton's "The Ants of North America"; thirty-eight resemble just as closely drawings in Smith's 1947 synopsis. There are no photographs.

The author professes great admiration for Creighton's "The Ants of North America," but he ignores one of Creighton's most laudable achievements: the elimination of the variety. Consequently we have a California list of 184 kinds of ants, *i.e.*, species, subspecies and varieties. For each kind a "habitat range" is given; this is merely a list of the states and provinces from which the ant has been reported; after this comes "California distribution." The book is based on about 1070 locality records, of which Cook is credited with 70! Is it utterly unreasonable to expect that a *book* on the ants of a state as large and diversified as California should be based on more material and that its author should have more field experience before writing it?

Although the author deplores the confusion resulting from the description of new forms of ants on the basis of inadequate material, he has not hesitated to describe in this book "Procratium californicum n. s. T. W. Cook" (p. 45) based on a single male; "Pogonomyrmex barbatus spadix, new species" (p. 98) and "Pogonomyrmex californicus nitratus, new species" (p. 99)—each based on a single worker, but neither occurring in California; and "Lasius (Chtonolasius) helveolus, n. s., T. W. Cook, 1950" (p. 327) based on three workers.

Myrmecologists will be obliged to consider this book because of the new forms described and because of the additions to the California fauna. But all that could have been incorporated in a supplement to Mallis' annotated list (1941) which could probably be sold for 25 cents.—GEORGE C. WHEELER.

THE BIOLOGY OF PARAMECIUM, by RALPH WICHTERMAN. Pp. xvi+527, 141 figs. The Blakiston Co., New York. 1953. Price $9.00.

This attractive book, according to the publishers the first in the English language to deal exclusively with Paramecium, promises to be a mine of information on a protozoon to which practically every zoology student is introduced in his elementary course and which has become an interesting laboratory animal for the cytologist, geneticist, and physiologist. An extensive bibliography (pp. 433–505), including a list of motion picture films, is given. Fittingly, the book is dedicated to Antony van Leeuwenhoek.—M. T. J.

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HEPTACHLOR

CONTROLS THESE INSECTS

Alfalfa Weevils, Ants, Argentine Ants, Cotton Boll Weevils, Cabbage Maggots, Chinch Bugs, Corn Borers (European), Corn Rootworms, Cotton Thrips, Cowpea Curculio, Crickets, Cucumber Beetles, Cutworms, European Chafer, Eye Gnats, Fleas, Flea Beetles, Garden Webworms, Grasshoppers, Japanese Beetles, Leaf Miners, Lygus Bugs, Mormon Crickets, Mosquitoes, Narcissus Bulb Flies, Onion Maggots, Onion Thrips, Plum Curculio, Rapid Plant Bugs, Screwworms, Seed Corn Maggots, Serpentine Leaf Miners, Spittle Bugs, Sugar Beet Root Maggots, Sweet Clover Weevils, Tarnished Plant Bugs, Tobacco Flea Beetles, Tomato Fruitworms, Tuber Flea Beetles, Turnip Maggots, Western Harvester Ants, White Grubs (June Beetles), Wireworms . . . *and many others.*

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